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Fish swimming performance database and analyses

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Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

Fish speed and stamina, locomotion and the mechanics of fish swimming, are important to the development and design of passage, exclusion, and guidance systems for fish. Such systems include fishways, fish bypasses, and culverts to assist fish to move upstream or downstream of obstructions; fish screens, fish louvers, and bar racks to exclude fish from harmful environments; fish barriers to exclude invasive species. Swimming speeds and endurance vary with species and body morphology, fish length, water temperature and other variables. Fish swimming speeds are classified as burst, prolonged, or sustained. Data on fish swimming performance are collected from swim tests conducted in swim tunnels or respirometers (also known as swim chambers or stamina tunnels). Field studies with culverts to determine whether fish are able to navigate in upstream migrations have provided data on water velocities and passable culvert lengths. More recently data from volitional fish tests in open channels (flumes or raceways) have been collected. Studies on fish swimming performance and data availability have been increasing. Significant gains in knowledge and better understanding of fish biomechanics have been made. This report presents and summarizes an extensive data base on fish swimming performance generated from the literature. This effort utilized data from a large number of studies since 1990 when the first and much smaller database was produced. Extensive data scrutiny and analyses of the available data were performed. Large variability in swimming performance is indicated. Fatigue curves or fish speed-time regressions were developed for individual species. There are insufficient data for many species and significant regressions are not available for these fish. Dimensionless variables allowed more global data analyses for groups of species and the ability to use limited data sets. Significant speed-time regressions (fatigue curves) were developed for six fish groups: Catfish and Sunfish; Eel; Herring (Clupeidae); Pike; Salmon and Walleye; and Sturgeon. The large variability in the data is reflected in these curves. Swim distance – water velocity curves were derived from each of the groups. Derived swim distance estimates were in good agreement with available swim distance data. Ranges of swim distance estimates allow the level of protection needed for a particular fish population to be considered in specific projects.

Analyses et base de données des performances natatoires du poisson

RÉSUMÉ

La vitesse et l'endurance du poisson, sa locomotion et son mécanisme de capacité natatoire sont importants pour la conception et la mise en œuvre de passes à poissons ou de dispositifs d'exclusion et d'orientation du poisson. Ces mécanismes sont multiples; il s'agit notamment de passes migratoires, de contournements et de ponceaux qui aident le poisson dans sa montaison ou son avalaison en cas d'obstacles, mais aussi de grilles, d'écrans hydrodynamiques et de grilles à barreaux pour exclure le poisson des milieux qui lui sont nuisibles; et enfin de barrières à poissons pour exclure les espèces envahissantes. La vitesse de nage et l'endurance varient d'une espèce à l'autre et selon la morphologie et la longueur du poisson, la température de l'eau et d'autres variables. Les vitesses de nage du poisson sont qualifiées de vitesses de pointe, prolongée et soutenue. Les données sur les performances natatoires sont collectées à partir de tests réalisés dans des tunnels de nage et des respiromètres (également désignés par les termes chambres de nage ou tunnels d'endurance). Des études sur le terrain réalisées avec des ponceaux pour déterminer quand la montaison du poisson est possible ont fourni des données sur les vitesses de courant rapides et les longueurs de ponceau franchissables. Plus récemment, on a recueilli des données tirées de tests de nage à la vitesse « volontaire » des poissons dans des chenaux ouverts (canaux surélevés ou canalisations). Les études sur les performances natatoires des poissons et la disponibilité des données sont de plus en plus nombreuses. Les connaissances en la matière et sur la biomécanique du poisson ont considérablement progressé. Le présent rapport présente et résume une base de données exhaustive sur les performances natatoires des poissons, produite à partir de la littérature spécialisée. Ce travail s'est fondé sur un grand nombre d'études réalisées depuis 1990, date à laquelle la première base de données, nettement moins complète, sur le sujet a été créée. Les données ont été minutieusement examinées et analysées en profondeur. Des variations importantes ont été constatées dans les performances natatoires. Des courbes de fatigue ou des régressions vitesse-temps ont été établies pour différentes espèces. Pour de nombreuses autres, les données sont insuffisantes et les régressions ne sont pas disponibles. Des variables adimensionnelles ont permis de réaliser des analyses de données plus globales pour des groupes d'espèces de poissons et d'utiliser des ensembles de données limités. Des régressions vitesse-temps significatives (courbes de fatigue) ont été établies pour six groupes de poissons : groupe des barbues de rivière et des malachigans, groupe des anguilles, groupe des clupéidés (hareng), groupe des brochets, groupe des saumons et des dorés jaunes, et groupe des esturgeons. Les courbes reflètent la grande variabilité des données. On a calculé des courbes distance de nage – rapidité du courant pour chaque groupe. Les estimations de distance de nage obtenues concordaient avec les mesures disponibles de distances de nage. Les fourchettes d'estimations des distances de nage permettent de prendre en considération le degré de protection nécessaire pour une population de poissons donnée dans les projets.

1.0 INTRODUCTION

Fish speed and stamina, locomotion and the mechanics of fish swimming, are important to the development and design of passage, exclusion, and guidance systems for fish. Such systems include fishways, fish bypasses, and culverts to assist fish to move upstream or downstream of obstructions; fish screens, fish louvers, and bar racks to exclude fish from harmful environments; fish barriers to exclude invasive species (Katopodis 2005). Swimming speeds and endurance vary with species and body morphology, fish length, water temperature and other variables. Beamish (1978) provides a classification of swimming speeds and a review of performance measurement methods. Fish swimming speeds are classified as burst, prolonged, or sustained. Burst speeds, which are the highest fish can attain over very short times (endurance <20 s), involve fast glycolytic white muscle fibres. Energy is derived from anaerobic processes. Burst or dart speeds use high power output to support sprints and fast starts and result in rapid fatigue. Fish use burst speeds to capture prey, avoid predators, or negotiate high water velocities. Sustained or cruising speeds are low speeds fish can maintain indefinitely without fatigue. Fish use mostly slow oxidative red muscle fibres providing fuel through aerobic processes. Sustained speeds use low power output to support long endurance swimming. Fish use sustained speeds for routine activities, such as foraging, holding, and schooling. The intermediate category of swimming speeds is known as prolonged, with fish endurance from approximately 20 s to 30 minutes ending in fatigue. Prolonged speeds involve both red and white muscle fibres for locomotion, with energy provided by both aerobic and anaerobic processes. Critical speed is a special category of prolonged speeds, for specific endurance times and is measured in swimming chambers (Brett 1964).

Studies on fish swimming performance and data availability have been increasing. Significant gains in knowledge and better understanding of fish biomechanics have been made (Katopodis 2005; Shadwick and Lauder 2006). Specific information on how long (endurance time) or how far (swim distance) particular species are capable of is limited or not available.

2.0 FISH SWIMMING PERFORMANCE DATA

2.1 DATA SOURCES

All data used in this analysis were collected from publications obtained from the English language literature. Relevant publications and data sources were identified using key words to search various electronic bibliographic databases (e.g., Aquatic Science and Fisheries Abstracts). Publications obtained from the literature included peer reviewed articles from scientific journals and books, as well as; grey literature sources (scientific information published reports; internal documents; conference proceedings; dissertations; technical specifications and standards). Some data were supplied directly from researchers in response to requests by the authors.

The literature contains a large and diverse collection of information related to the mechanical, physical, chemical, biological and physiological aspects of swimming in fish. Approximately 2000 references, published from 1945 to 2010, were collected and scrutinized for relevant swimming performance data. A bibliography of the publications was created using the ProCite software package (Thompson Reuters, Carlsbad, CA, USA).

The focus of the data extraction from the literature was on tests that measured swimming performance in terms of speed, time and/or distance.

Preliminary screening of the collection of publications yielded a number of references that were flagged as potential sources with actual swimming performance data for species whose lifecycle includes a freshwater phase. These references provided the numerical data which populated the generated swimming performance database. The majority of the publications obtained from the literature did not contain any numerical data related to measurement of swimming performance.

Over 80% of the data used in the analyses reported are from the primary literature. Although intensive literature searches and data extraction efforts were made, given the sheer volume and diversity of swimming performance literature available, some data may have been missed. Nevertheless, the assembled collection represents a variety of data collection methods and a large number of species and sizes.

2.2 MEASUREMENT OF SWIMMING PERFORMANCE

Historically, swimming performance has been measured in terms of speed, time, and distance using a variety of methods that have evolved over time. Beamish (1978) provides a historical perspective on the evolution of the various fish swimming performance tests. A brief description of the test methods reflected in swimming performance data collected from the literature follows.

There is no universal standard or method that defines how fish swimming performance is to be measured. Testing methodologies have evolved based on study objectives and the introduction of new techniques and instrumentation. Many of the datasets collected from the literature utilize the same fundamental techniques to measure swimming performance, however specific details are often modified in studies and this can influence the data that is generated.

Swimming performance is often used to evaluate the effects of environmental or other factors such as water quality (contaminants), water temperature, training, diet, tagging, etc. by measuring the difference in performance between the treatment and control group.

Modern test methods to measure swimming performance in fish are often classified as a forced or volitional swim test (see Table 2 for summary details).

2.2.1 Forced Swim Tests (Respirometer Data: fish speed and endurance time)

Most available data are from swim tests conducted in swim tunnels or respirometers (also known as swim chambers or stamina tunnels; Fig. 1). The swim tunnel is widely used because of its compact size and limited water requirements which allows great flexibility when and where fish can be tested. The swim tunnel is analogous to the treadmill for running where fish hold position and swim at the same speed of water flowing through the tunnel, just as a runner on a treadmill holds position by running at the speed of the treadmill. Two types of forced swim tests are distinguished, the fixed velocity test and the increasing (critical) velocity test. Swim tunnel tests are classified as a forced swim test because fish must swim at the speed of the water velocity in testing apparatus and fish are often encouraged to continue swimming through physical stimulation when they first fall back against the downstream barrier. Swim tunnel tests measure swimming performance in terms of swimming speed and endurance time.

Fixed Velocity Test: In this test, the water velocity is fixed and the time for fish to fatigue is measured. This test may produce data over a range of fish endurance times including burst and prolonged speeds. A fatigue curve which plots endurance time as a function of swimming speed can be produce by testing a fish species of a certain length at different swim speeds and combining the data on a graph (Brett 1964).

Increasing (Critical) Velocity Test: The critical or highest swimming speed is measured by subjecting a fish species of a certain length to a progression of increasing velocity steps maintained for fixed time periods until the fish ceases to swim. Critical speed was originally based on time increments of 60 minutes (Brett 1964). Various time steps and velocity increments have been used since, particularly in more recent studies. Although this test was primarily intended to measure prolonged or sustained speeds, recent literature includes tests with time steps as short as 5 minutes or less. The Increasing Velocity Test may also provide respirometric data, as it is used for measuring oxygen consumption. The increasing velocity test is the most widely used method to measure swimming performance based on the data reported in the literature.

Critical swim speed (U_{crit}) is calculated using the following equation:

$$U_{crit} = U_m + (t_m / \Delta t)\Delta U \qquad (1)$$

U_m = highest velocity at which fish swam for the full time interval

ΔU = incremental speed step

t_m = time fish swam at fatigue velocity (last velocity step)

Δt = prescribed time step for the incremental speed step

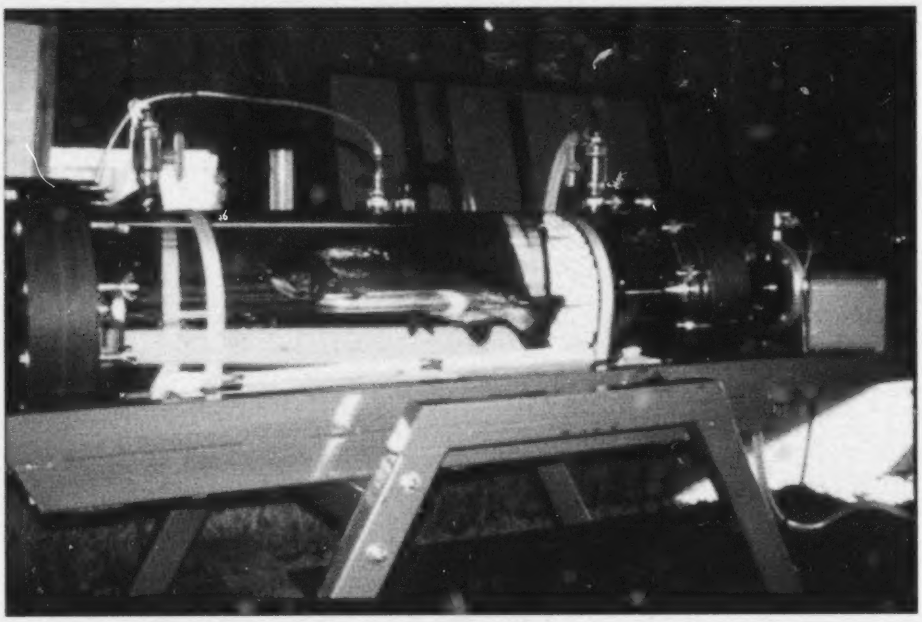

Figure 1. Swim tunnel (stamina tunnel, swim chamber or respirometer)

2.2.2 Volitional Swim Tests

Laboratory experiments provide useful data on predicting fish swimming performance. Verification of performance predictions though is an important aspect, as field conditions can rarely be matched in the laboratory. This verification though may take several years before various species and life stages are tested for a wide range of hydraulic conditions. Laboratory studies with various swim chambers furnish data for non-volitional fish responses. Field studies contribute data for volitional responses over a limited range of conditions and with many variables interacting simultaneously. Controlled experiments conducted with more realistic test conditions offer a way of developing better design criteria for habitat access and fish exclusion systems.

Volitional swim tests measure fish movement through a fixed length open channel (flume) or culvert. In these tests, fish are allowed to freely enter the channel or culvert and stage an attempt at passage by moving upstream against water flowing through the device. Open channel and culvert volitional swim tests measure swimming distance, in addition to the swimming speed and endurance time. In the volitional test, fish typically swim faster than the speed of flow and the swimming speed relative to water velocity is controlled by the fish. The ability to generate higher water velocities in the open channel flume tests compared to swim tunnel tests allows testing of higher swimming speeds. Most volitional tests involve swimming speeds that are maintained for 60 seconds or less compared to forced swim tests where swimming speeds can last from minutes to hours.

Open Channel Data

In the late 1950s, Weaver (1963) conducted a series of experiments on migrating salmonids using various open channel configurations at the Bonneville Dam Fisheries Research Laboratory (Columbia River). These included a rate of movement test where time to swim a 30-foot (9 m) timing zone against water velocities ranging from 2 to 16 feet per second (0.6 to 4.9 m/s) was measured. The maximum swimming distance that could be achieved in an 85-ft (26-m) channel for water velocities of 13.4 and 15.8 fps (4.1 and 4.8 m/s) was also measured.

A special facility, an Ecohydraulics flume or raceway (also refered to as I-H flume), was developed to allow volitional fish responses under controlled conditions and assist with observations using telemetry (Katopodis 2005). A temporary Ecohydraulics flume was used to measure fish swimming ability in the field for several water velocities, including burst speeds, distances traveled and endurance times, and to observe fish behaviour (Colavecchia et al. 1998; Fig. 2). Mean water velocities in this 18 m long flume (0.50 m wide and 0.61 m deep; 2% slope) ranged from 1.6 – 3.2 m/s and swimming performance data on adult Atlantic Salmon with coded radio tags were obtained. Fish were able to use a pool located at the downstream end to enter the flume on their own. A mobile version of the Ecohydraulics flume (Fig. 3) was also developed in collaboration with the University of Alberta (also refered to as I-H flume; Shepherd et al. 2007). This version allows testing near rivers and lakes, as well as at hatcheries, field stations or laboratories, since it is completely self-contained and consists of five detachable components for ease of transportation.

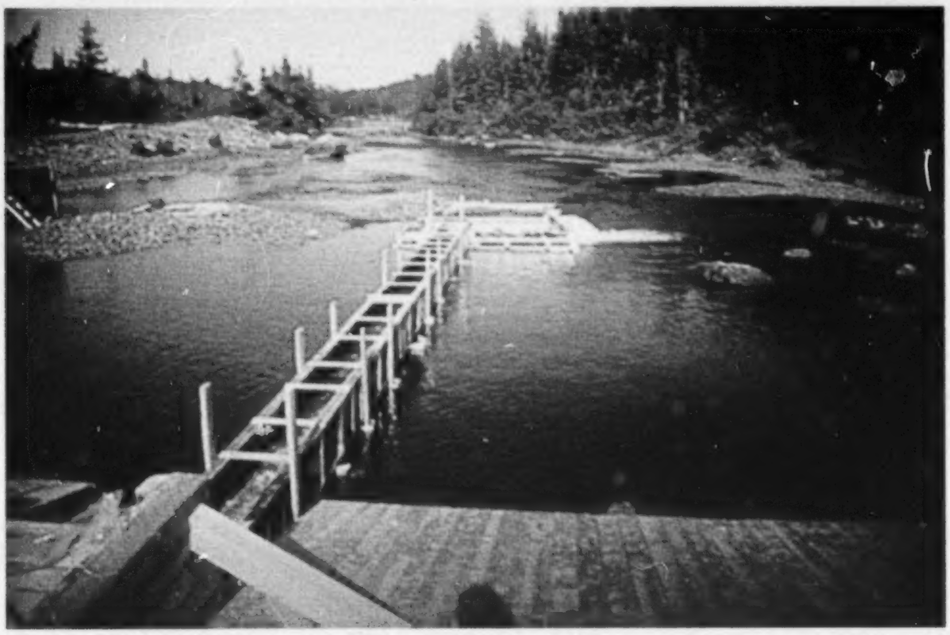

Figure 2. Temporary Ecohydraulics Flume (channel or raceway) in NL

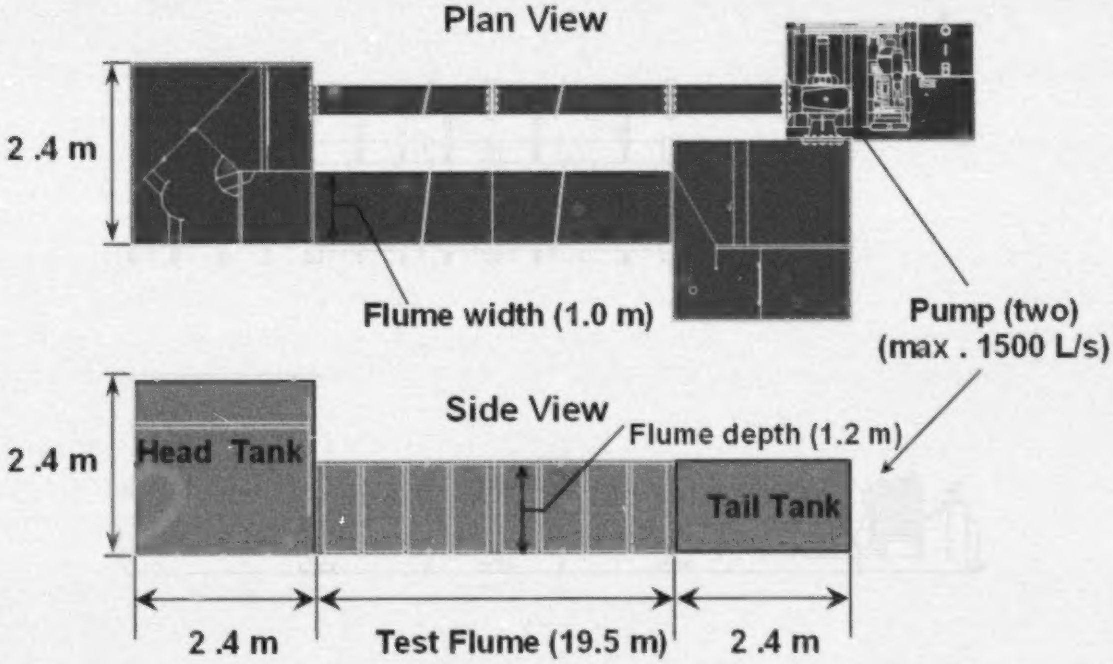
Plan View
2 .4 m
Flume width (1.0 m)
Pump (two)
(max . 1500 L/s)
Side View
2 .4 m
Head Tank
Flume depth (1.2 m)
Tail Tank
2 .4 m
Test Flume (19.5 m)
2 .4 m

Figure 3. Diagram of Mobile Ecohydraulics Flume (open channel raceway)

Some studies, simply report percentage passage for a given distance and water velocity (Peake 2008a). Percent passage is the ratio of number of fish that completed passage to the number of fish that attempted passage. In the open-channel volitional swim test fish can freely choose to leave the downstream holding tank and make an attempt at passage by entering the test channel. Results from open-channel volitional swim tests have shown large variations in the number of fish that leave the staging area to attempt passage. For example, Table 1 shows the percentage of fish by species and water velocity (1.5 to 4.5 m/s) that attempted passage by leaving the staging area (Haro et al. 2004). It is interesting to note the variations in passage attempts by species and water velocity and the number of cases where attempts were less than 50 percent. For example, only 30 percent or less of walleye attempted to swim the flume. Performance measurements from this test were based only on the fish that attempted passage. The significance of the relatively large numbers of fish in a test population that chose not to participate in a given test is a potentially important consideration for the performance results. Does water velocity influence the participation rate by providing either a positive or negative influence (i.e. higher velocities may increase participation for some species and decrease participation for others)? The level of participation of a test population is usually much higher for forced swim tests compared to volitional swim test, because in the forced test fish are typically physically placed in the test chamber. The higher percentage of fish tested in the forced swim test may capture a wider range of performance compared to the volitional swim test.

Table 1. *Summary of passage attempts by species and water velocity for open channel volitional swim test (Haro et al. 2004).*

Species	Percentage Attemping Passage			
	Water Velocity (m/s)			
	1.5	2.5	3.5	4.5
American shad	86	68	71	33
Alewife	55	30	37	
Blueback herring	17	18	34	
Striped bass	33	38	33	70
Walleye	24	30	22	
White sucker	65	41	36	49

In addition to the rate-of-movement and maximum distance of ascent tests noted above, the percentage passage has also been used as a performance measure for open-channel volitional testing. In Peake 2008, passage success was reported as a function of attempts by dividing the number of fish that are able to successfully swim the entire channel length by the number of the fish that entered the channel from the staging area (e.g. 75% passage rate when 20 fish entered the flume and 15 swam the entire flume length). This type of data provides a relative measure of performance which is helpful but limited in terms of providing maximum performance limits of individual fish. Data from this test was not used in data analysis other than to check the derived swimming distances to see if they were reasonable.

Culvert and Pipe Data

Field studies with culverts to determine whether fish are able to navigate in upstream migrations have provided data on water velocities and culvert lengths fish swum through. Culverts have also been used in laboratory studies. Washington State Department of Transportation and Department of Fish and Wildlife developed a culvert test bed that was used to test upstream passage of juvenile salmon and collected detailed hydraulic measurements for plain and baffled culverts at different slopes (Pearson et al. 2006). The authors noted that juvenile Coho Salmon were able to find and use the low velocity pathways to achieve culvert passage.

Swimming performance measurements from fish passage tests in culverts is complicated by the variation in water velocities that occur in the cross-sectional area of the culvert. Small fish are known to take advantage of the low velocity zones that occur along culvert walls due to boundary-layer effects (Figure 4). The culvert cross-section consists of different velocity zones and the zone that the fish selects as its swimming path is defined as the occupied zone. Water velocity in the occupied zone can be much lower than the average culvert velocity and therefore it is very important to use the correct water velocity criteria when assessing fish passage in culverts. Performance results reported using average culvert velocities when fish actually swam in zones of lower velocity can be misleading and create the illusion of exceptional performance. This is an important consideration in using performance data reported in the literature and in defining velocity criteria for fish passage in culverts. Average velocity criteria which is often used, may overestimate the velocity requirements of smaller fish sizes that use the lower velocity zones, however the ability to reliably predict movement through the low velocity zone is challenging. Nevertheless, the percentage of fish that passed through a culvert is useful as a check of swim distance estimates.

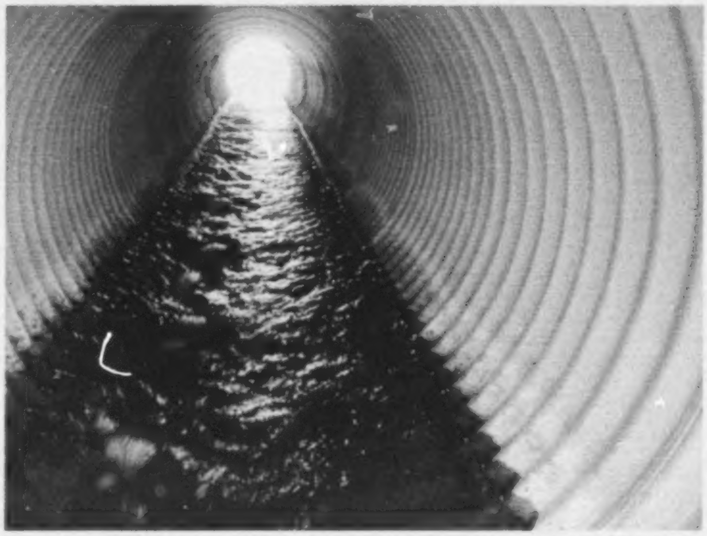

Figure 4. Field studies with culverts and fish passage.

Slatick (1970 and 1971) performed a series of experiments that measured passage times and passage rates for migrating adult salmon (Chinook, sockeye and coho) at the Bonneville Dam (Columbia River) using plain smooth pipes of various lengths, diameters and configurations (inclined, bends), illumination levels and entrance designs. These tests did not measure maximum performance (fish were not tested to fatigue); however, these experiments did provide information on swimming speeds relative to water velocity and the passage rates in plain (smooth) pipes. Data from these experiments are useful as a check of swim distance estimates.

2.2.3 Other Test Methods

Fish wheel – The following is a description of the fish wheel and was taken directly from Videler and Wardle (1991). "An annular channel, rectangular in cross-section and filled with water, is rotated against the swimming direction at the speed of the fish. The fish remains stationary relative to the observer or camera. The animal chooses its preferred swimming speed and swims in static water. Wall effects can be neglected as long as the fish swims near the centre of the channel and its size is small compared with the width of the channel. The largest fish wheel by Bainbridge and Brown (1958), with a diameter of 2.25 m was designed to avoid slippage between water and channel during fast accelerations to higher speeds. The rotational velocity of the wheel is proportional to the average swimming speed of the fish. The response time of the operator to the movements of the fish can be a serious source of error. It is expected to be small during steady swimming and will increase when swimming becomes more erratic. A further disadvantage of fish wheels is that weight problems limit their size, resulting in swimming along circular paths."

Bainbridge (1960) used a fish wheel to measure endurance times at burst speeds in dace (*Leuciscus leuciscus*), Rainbow Trout (*Oncorhynchus mykiss*) and goldfish (*Carassius auratus*). Electric shocks of different strengths were used to generate high burst speeds in the fish, the speed and duration of the burst was captured by an oscilloscope that recorded the response of an operator who rotated the wheel in the opposite direction of the burst. Lag time and accuracy related to human reaction to the burst were identified as underestimating the burst performance (Webb, 2006). A comparison with other data showed a lower burst performance for this dataset and it was subsequently flagged and excluded from further analysis.

Fast Start (Escape or Startle Response) Swim Test - fast-starts are brief, sudden, high-energy bursts of unsteady swimming, used by many fish species to escape predators or capture prey (Harper and Blake, 1990). Fast-starts are a form of burst swimming lasting less than 1 second. A detailed review of fast start swimming can be found in Domenici and Blake (1997) and Wakeling (2001). Fast starts are measured with high speed video or an accelerometer and the focus is usually on the acceleration phase which starts with the fish at rest (speed = zero) and ends when maximum swimming speed is reached.

Harper and Blake (1990) measured fast start (escape) performances of Rainbow Trout *Salmo gairdneri* and Northern Pike *Esox lucius*, mean lengths 32 cm and 38 cm, respectively using subcutaneously implanted accelerometers. Fish were startled by thrusting a wooden pole towards their head which was noted to produce a more forceful fast-start than an electric shock which had been used by Webb (1975). Mean maximum acceleration rates for pike were 120.2 ± 20.0 m s^{-2} and 59.7 ± 8.3 m s^{-2} for trout.

Fast start data, although useful, were excluded from analysis because most of the published data were for the acceleration phase which was of extremely short duration (fractions of a second) and presented a challenge in defining corresponding endurance time and swimming speed. The time duration that fish could hold the maximum swimming speed was usually not included in these studies.

Other Swim Tests – include variations of the increasing velocity test that were developed to meet specific study objectives and are described below.

- Ramped critical swimming speed test (Jain et al. 1997; Jain and Farrell 2003). This test is a variation of the increasing velocity test where water velocity is initially accelerated to 50 to 75% of the critical swimming speed over a 5- to 6-min period followed by fixed time steps (20 or 30 minutes) for the remainder of the test. Critical swimming speed (Ucrit) values produced using the ramp-Ucrit protocol were found to be similar to the traditional test where longer time intervals are used from the start of the test.

- Constant acceleration tests (Umax) by Farrell (2008) and Uburst by Reidy et al. (1995) are similar to the increasing velocity tests, however the time step between velocity increments is 1 minute which is much shorter than traditional tests. When the velocity increment is divided by the time step, the resulting parameter is viewed as acceleration.
- Sprint Performance - Nelson et al. (2002); Handelsman et al. (2010) highest swimming speed attained in flume based on limited swimming distance;

2.3 GENERATION OF THE ELECTRONIC DATABASE

The literature review identified a large and diverse collection of data on fish swimming performance from both laboratory and field studies with a variety of methodologies and actual measurements scattered among many different publications. The measurements in most publications were quite focused and tended to capture only part of the overall performance range for the fish. Critical swimming speed is the performance measure most reported in the literature. Very few publications in the literature measured the complete performance range at the species level based on endurance times and swimming speeds. Many publications report the critical swimming speed based on a specific time step which is basically a single point on the fatigue curve. In an effort to better utilize the highly fragmented and widely scattered data contained in the literature, a database of fish swimming performance measurements was created using data extracted from the literature. This database is refered to as the "Ichthyomechanics Database".

Developing and populating the database was an iterative process that evolved during the course of this project and was based on becoming familiar with the data and refocusing collection efforts on data that was most useful in terms of estimating performance. A diverse set of swimming performance measurements for a variety of fish species was assembled during the initial data collection. An assessment of the data revealed limitations and concerns with some of the data collection related to missing information; data from tests with treatments that affected performance (e.g., exposure to contaminants); data where quality concerns were identified by other researchers; data from experiments where methodology resulted in uncertainties in the measurements. The assessment resulted in certain data points being flagged due to limitations and excluded from further analysis. The assessment was also helpful in establishing criteria for collecting additional data from the literature in terms of targeting the most relevant data. The decision was also made at this time to focus on freshwater species or species that use freshwater during their life cycle (e.g., anadromous or catadromous species) based on priorities and work load. Existing marine species in the database were flagged and excluded from further analysis.

New swimming performance data are constantly being published in the literature and there is a lag between the time data become available and opportunities to process and add these to the database. Additional data from newer publications were included when the database was further updated in 2013. These updates mainly focused on data for species not represented or under-represented in the database or filled identified gaps in the range of swim speed data (e.g., new data in the burst speed range).

Studies on fish swimming performance by several methods have produced data for several species, sizes, endurance times and distances. The Ichthyomechanics Database is a Microsoft Access database that was developed to archive fish swimming performance data collected from the literature.

The Microsoft Access Ichthyomechanics Database is a relational database made up of swimming performance data collected from the literature. Most references contain a method and materials section and a table or graph containing the actual swimming performance results. Most publications contain a number of individual swimming performance results corresponding to a common method and group of fish. The database was designed using a hierarchical structure with common information and detailed swimming results stored in separate tables. Common fields are used to link the tables. The rationale behind using separate tables was to maximize the efficiency of the database by minimizing duplication. The database consists of a series of datasets that correspond to the data that was collected from a particular reference or data source from the literature (e.g., paper or report).

Forms were developed to assist with data entry and editing. Queries were developed to assist with data browsing and retrieval.

A **Data Flag** field was added to the database as a way of identifying and keeping track of specific data records or groups of records that did not fit the screening criteria for the swimming analysis in terms of species, test methodology and required data. The database also includes a text field where a brief explanation about the particular flag can be written.

In addition to the data flags, the database also contains a field for keeping track of censored data where the maximum ability of the fish in terms of swimming time or distance in not reached during testing. In swim tunnel tests, censoring is used where the time limit of the test is reached before the fish is fatigued or in open channel flume or culvert tests, censoring is used when fish swim the entire flume length. For censored data, fish can swim longer or further that what was measured.

2.4 DATA CHARACTERISTICS

2.4.1 Published Data (Preprocessed Data)

Published data on fish swimming performance are often reported using average or median values based on measurements from individual fish that are part of a test group. The performance data for the individual fish or raw data are usually not provided when grouped data are presented. Attempts to obtain missing raw data by contacting researchers, when developing the data collection, was met with limited success. Raw data were available for some swimming performance studies. For publications that contained both processed data (mean or median values) and the underlying raw data, the raw data were selected for the database. Data with the lowest amount of processing were selected for the database, when available. The term "preprocessed data" was used to describe any data collected from the literature which included both raw and grouped data. Preprocessed data were used to differentiate actual data from the literature from data that was produced from additional processing related to this project.

Table 1 contains summary information on the fish swimming performance endurance data that was used in the analysis. The preprocessed data consisted of 16,926 swimming speed and time measurement records which corresponded to 131 different fish species and 27,030 individual fish (some measurements were based on multiple fish) from 132 different data sources; see Table 1 for details.

The database contains values for fish speed, U in m/s, endurance time, t in s, swimming distance, X in m, fish length, l in m, and water temperature, T in °C. The Ichthyomechanics Database includes the following information: species (scientific and common name), test method (critical velocity, endurance, flumes, or culverts), swimming time and speed for endurance tests, velocity and time increment and critical velocity for critical velocity tests, water temperature, fish length; length type (i.e., fork, standard, total etc.), data source (author, title, year, publication etc.), number of fish tested, regressions of swimming speed versus fish length for specific endurance times or endurance time vs swim speed as reported in the literature, data flags and relevant comments. The data base may be consulted for information on specific species, although many species either have very limited data or are not represented at all.

A set of endurance plots for the published or preprocessed data collection is presented in Appendix 1 - Graphs Series A, where a detailed description about the graphs is included in the introductory page. Each graph is for a specific species and is plotted by reference which is the source of the data. The graphs are plotted using the traditional fatigue curve format and reflect a data screening process that removed or excluded certain data that had errors or were outside the scope and focus of this analysis (e.g., marine species are excluded). The screening process is discussed in an earlier section

2.4.2 Processed Data

As stated in the previous section, preprocessed data are used to identify the data collection as reported in the literature and includes measurements based on individual and groups of fish. Many studies have used swimming performance as the parameter to assess and compare effects of different treatments, where each treatment involves a test group made up of a number of fish. The use of multiple fish provides a more accurate estimate of how performance is impacted by capturing a range of abilities. Grouped performance data are usually based on individual measurements for fish of the same species, from the same population and of similar size subjected to the same treatment and test procedure. Grouped data are usually reported as a mean or median with a standard error or standard deviation.

To bring more consistency to the data collection in terms of swimming performance results, individual fish performance data were grouped where possible. Grouping of the individual performance data were based on the same general criteria used in the literature where the data from a particular study or data source were grouped (i.e., species, size and treatment were comparable and the same test was used). A range of plus or minus 10% for parameters such as length or temperature was typically used when grouping data. A new data collection set was generated by combining the existing grouped data from the preprocessed collection and the grouped data from this processing exercise. This new data collection set was identified as the "processed data" because of the grouping and some screening of the preprocessed data.

The data screening process included limiting endurance time to 30 minutes or less which corresponds to the performance range that is typically used to define design criteria for fish passage and related projects which was the focus of this work. Fish passage facilities that require swimming speeds to be maintained for more than 30 minutes of continuous effort, are usually designed with resting areas that allow higher swimming speeds and shorter swim times. In terms of design complexity and cost, it is often more effective to achieve passage using a series of steps where periods of continuous swimming are balanced with rest opportunities to accomadate higher water velocities and reduce the length of the fishway.

Processed data sets were derived and were used for further analysis. Table 2 provides summary information on the processed data which consists of 2,045 swimming speed and time measurements, corresponding to 122 different fish species and 22,506 individual fish measurements, from 117 different data sources. Detailed summary information on the swim speed–time processed data is provided in Appendix 2 in Table A1. Graphs of the swim speed–time processed data available are included in Appendix 1 – Series B for 122 species. In these graphs, data were limited to more practical endurance times of 30 minutes. These graphs depict the available swim speed–time data by fish species and reference. These graphs indicate similar characteristics for the swim speed–time processed data as those for the preprocessed data. Furthermore, they indicate that more complete data sets are available for anadromous species, while limited or no data are primarily associated with freshwater fish species. The data extraction and preparation procedure used to assemble the database collection is illustrated with an example in Appendix 3. Preprocessed data presented in original sources, include data on individuals and various ways of grouping or averaging fish speeds, times and distances. Appendix 3 explains further the efforts made to covert the mixed preprocessed data to the more evenly treated processed data.

Table 2. Data summary of preprocessed and processed data used in the analysis. Measurement count is the number of individual data measurements collected from the literature, some measurements were based on more than one fish.

Parameter	**Swim Speed - Time Data**		**Distance-Velocity data**
	Preprocessed	**Processed**	**Processed**
By Record type			
Data Source (# of different sources)	132	117	16
Species	131	122	22
Measurements	16,926	2,045	493
Fish (# of individuals)	27,030	22,506	17,888
By Test Method and Apparatus;measurement count (fish count)			
Forced Swim Test			
Fixed Velocity - OC flume (constrained)	4,596 (4,629)	115 (3,339)	
Fixed Velocity - Rotating chamber	289 (469)	60 (309)	
Fixed Velocity – Stamina Tunnel	3651 (7,388)	751 (6,193)	
Increasing velocity - OC flume (constrained)	20 (47)	5 (47)	
Increasing Velocity – Stamina Tunnel	6,847 (10,976)	853 (9,049)	
Volitional Swim Test			
Fixed Velocity - Open channel (OC) flume	1,523 (3,521)	261 (3,569)	329 (5,769)
Fixed Velocity - Culvert			123 (10,657)
Fixed Velocity - Pipe			41 (1,562)

3.0 ANALYSES OF INDIVIDUAL SPECIES DATA

A first level of data analysis is depicted by graphs of fish speed vs time for individual species, using the preprocessed data available in the Ichthyomechanics Database (Appendix 1 – Graphs Series A). In this series, the data are presented using the traditional fatigue curve format with swimming speed in body lengths per second and endurance time in seconds. More information about the graphs in this series is contained on the Appendix 1 - Graphs Series A introductory page.

A second series of graphs was produced using the processed data collection (Appendix 1 - Graphs Series B). This series uses the same data as in Graphs Series A, however as described in a previous section some individual performance data were grouped and some data were screened. Graphs are plotted by species and the reduction in species from 131 in Series A to 122 in Series B was there result of screening. For example any species that only had data with endurance times greater than 30 minutes were screened and excluded.

For a well-defined speed-time curve, data over the burst, prolonged and at least the start of the sustained fish speeds are needed, as well as a representative range of fish lengths. It is clear from the graphs in Appendix B that such data are available for just seven species only:

- Chinook (Fig. B-090) and Coho (Fig. B-086) Salmon
- Steelhead Trout (Fig. B-088)
- Walleye (Fig. B-116) and White Sucker (Fig. B-016)
- Burbot (Fig. B-059 and Sea Lamprey (Fig. B-094)

Table 3 summarizes information on the above species and includes five others which have good data sets but lack short burst speeds. These are Barbel (Fig. B-012), Brook Trout (Fig. B-114) and Brown Trout (Fig. B-111), European Grayling (Fig. B-122) and European Eel (Fig. B-009). It is worth noting that for many fish species data are available in a very narrow range of swim times, speeds or fish lengths. Regressions based on such a narrow range of swim times may provide reasonable estimates of fish performance only within limited conditions. There are several data sets though for various species which correspond to different ranges of speed-time and fish length. This may assist in constructing more complete speed-time curves if several species have similar swimming performance and could be grouped.

4.0 ANALYSES WITH DIMENSIONLESS VARIABLES

4.1 DIMENSIONLESS VARIABLES

Dimensionless analysis is used to investigate and generalize data. It is similar to using normalized variables. Dimensionless analysis leading to generalizations about geometric properties of circles serves to illustrate this concept. If several different size circles were drawn and for each the circumference and diameter were measured both in m, a property of all circles would result if the ratio of each circumference to the corresponding circle diameter was calculated. This ratio was known to Ancient Greeks as π, approximately equal to 3.14. Note that π has no specific units (m/m) and is dimensionless. Similarly, if the area of each circle was measured and was divided by the square of each corresponding radius, the ratio is π. Note that the ratio of area (m^2) to radius squared (m^2) is again dimensionless, as long as consistent units are used for both variables (i.e., both in m^2 not one in m^2 and the other in mm^2). Similarly in fluid mechanics, dimensionless parameters include the Froude and Reynolds numbers and drag coefficients. Functional relationships between drag coefficients and Reynolds number for spheres or cylinders in uniform flow, reduce to a single line for each shape.

For fish speed **U**, a common normalized variable is U/l or body lengths per second. Note that units are still involved (1/s). Another formulation though, using the gravitational acceleration (g in m/s^2) leads to a dimensionless variable for fish speed:

$$U_* = U/\sqrt{gl} \tag{2}$$

The denominator in Equ. (2) has the units of velocity (m/s) and is analogous to the celerity (c) or speed of a water wave with wave length, λ, equal to l. From basic wave theory, water wave celerity or speed is proportional to:

$$\sqrt{g\lambda} \tag{3}$$

It is worth noting that water wave period is proportional to:

$$\frac{1}{\sqrt{g/\lambda}} \text{ or } \sqrt{\lambda/g} \tag{4}$$

Note that the dimensionless fish speed in Equ. (2) represents a ratio of fish speed to the speed of a conceptual water wave with wave length equal to the fish length (Equ. 3). In a similar way, the wave period from Equ. (4), may be used to formulate a dimensionless fish endurance time:

$$t_* = \frac{t}{\sqrt{l/g}} \tag{5}$$

Using (2) and (5), it is possible to analyse fish speed-time data for all or several species together.

The dimensionless fish swimming distance (X_*) can easily be defined as:

$$X_* = X/l \tag{6}$$

Similar to the dimensionless fish speed of Equ. 2, the dimensionless water velocity (V_*) can be defined as:

$$V_* = V/\sqrt{gl} \tag{7}$$

4.2 FATIGUE CURVES

Fatigue curves are relationships between fish speed (*U*) and endurance time or time to fatigue (*t*). They typically take the form of power curves, similar to exponential decay curves. The shape of such curves indicates rapid reduction in performance from high burst speeds at short times to gradual changes in prolonged speeds at long times. Dimensionless fatigue curves, U_* vs t_*, can be derived as follows:

Fish endurance:

$$U_* = Kt_*^b \tag{8}$$

Using Equ. 2 and 5:

$$\frac{U}{\sqrt{gl}} = K\left(\frac{t}{\sqrt{l/g}}\right)^b \tag{9}$$

Rewriting (8):

$$U = K\sqrt{gl}\left(\sqrt{l/g}\right)^{-b} t^b \tag{10}$$

Or:

$$U = Kg^{\beta} l^{\alpha} t^b \tag{11}$$

Where: $$\beta = \left(\frac{1+b}{2}\right) \qquad (12)$$

$$\alpha = \left(\frac{1-b}{2}\right) \qquad (13)$$

And if $$A = Kg^{\beta} \qquad (14)$$

Simplifying (10): $$U = Al^{\alpha}t^{b} \qquad (15)$$

A dimensionless fatigue curve, U_* vs t_*, is plotted in Appendix 1 - Graphs Series C, for each of the 122 fish species, indicating the number of data sources for each species (i.e., references). Each of these graphs corresponds to a fatigue curve with dimensions in Appendix 2 – Table A2a. Table 3 lists fish species which may have sufficient data to develop individual fatigue curves and compares regression results when using ***U/l*** or Bl/s and dimensionless fish speed, U_*. In all cases U_* produces higher R^2 values. The dimensionless graphs in appendix 1 – Graphs Series C, which incorporate fish length, show good regressions for more species with sufficient data than the corresponding Series B graphs which use ***U/l*** or Bl/s. The 95% confidence intervals show large variability for many data sets, which include most of the species with the largest data sets:

- Atlantic Salmon, Fig. C-110
- Barbel, Fig. C-012
- Brook Trout, Fig. C-114
- Brown Trout, Fig. C-111
- Chinook Salmon, Fig. C-090
- Coho Salmon, Fig. C-086
- Dace, Fig. C-057
- European Eel, Fig. C-009
- European Grayling, Fig. C-122
- European Smelt, Fig. C-091
- Lake Sturgeon, Fig. C-003
- Pallid Sturgeon, Fig. C-117
- Rainbow (Fig. C-087), or Steelhead Trout (Fig. C-088)
- Sea Lamprey, Fig. C-094
- Walleye, Fig. C-116
- White Sucker, Fig. C-016

Table 3. Summary of fish species which may have sufficient data (i.e., burst and prolonged data for a range of fish lengths and reasonable fish speed vs time regressions; $R^2 > 0.4$) to develop and use as individual fatigue curves. R^2 – correlation coefficient; SEE – standard error of estimate; n – fish count

Species	Regression	Graph	R^2	SEE	n	Comments
Barbel	***U/l***	B-012	0.593	0.343	1178	Weak on burst data
	$U_\cdot$	C-012	0.713	0.264	1178	
Brook Trout	***U/l***	B-114	0.424	0.161	454	Weak on burst data
	$U_\cdot$	C-114	0.480	0.205	454	
Brown Trout	***U/l***	B-111	0.474	0.362	669	Weak on burst data
	$U_\cdot$	C-111	0.490	0.490	669	
Chinook Salmon	***U/l***	B-090	0.513	0.266	1214	
	$U_\cdot$	C-090	0.890	0.278	1214	
Coho Salmon	***U/l***	B-086	0.024	0.314	549	R^2 weak for ***U/l***
	$U_\cdot$	C-086	0.638	0.373	549	
Steelhead	***U/l***	B-088	0.153	0.227	1867	R^2 weak for ***U/l***
	$U_\cdot$	C-088	0.908	0.230	1867	
Walleye	***U/l***	B-116	0.933	0.221	221	
	$U_\cdot$	C-116	0.964	0.154	221	
White Sucker	***U/l***	B-016	0.883	0.148	287	
	$U_\cdot$	C-016	0.934	0.127	287	
European Grayling	***U/l***	B-122	0.425	0.340	1301	Weak on burst data
	$U_\cdot$	C-122	0.770	0.204	1301	
Burbot	***U/l***	B-059	0.670	0.523	100	
	$U_\cdot$	C-059	0.677	0.412	100	
European Eel	***U/l***	B-009	0.670	0.391	623	Weak on burst data
	$U_\cdot$	C-009	0.715	0.334	623	
Sea Lamprey	***U/l***	B-094	0.917	0.211	1000	
	$U_\cdot$	C-094	0.955	0.165	1000	

4.3 SWIM DISTANCE CURVES

Swim distance can be estimated from fish speed and time as follows:

Fish swim distance (X):

$$X = (U - V)t \tag{16}$$

Dimensionless swim distance curves $X_\cdot$ versus $V_\cdot$, can then be derived as follows:

Divide by $\sqrt{gl}$:

$$\frac{X}{\sqrt{gl}} = \left(\frac{U}{\sqrt{gl}} - \frac{V}{\sqrt{gl}}\right)t \tag{17}$$

Use Equ. 6 and 7and divide by $\sqrt{l/g}$:

$$\frac{X}{\sqrt{(l/g)(gl)}} = (U_* - V_*)\frac{t}{\sqrt{l/g}} \tag{18}$$

Simplifying:

$$X_* = (U_* - V_*)t_* \tag{19}$$

An optimum swim distance (X_o) may be estimated. Equ. (16) may be re-written by substituting U from Equ. (15):

$$X = \left(Al^a t^b - V\right)t \tag{20}$$

For optimum distance, set the derivative of X in Equ. (20) to 0:

$$\frac{dx}{dt} = (1+b)Al^a t^b - V = 0 \tag{21}$$

From Equ. (21):

$$t^b = \frac{V}{(1+b)Al^a} \tag{22}$$

From Equ. (22):

$$t = \left[\frac{V}{(1+b)Al^a}\right]^{1/b} \tag{23}$$

From Equ. (15) and (22):

$$U = \frac{V}{1+b} \tag{24}$$

From Equ. (24), (2) and (7):

$$U_* = \frac{V}{(1+b)\sqrt{gl}} \tag{25}$$

Therefore:

$$U_* - V_* = \frac{V-(1+b)V}{(1+b)\sqrt{gl}} = \frac{-b}{1+b}V_* \tag{26}$$

From Equ. (5):

$$t_*^b = \frac{t^b}{\left(\sqrt{l/g}\right)^b} \tag{27}$$

Using Equ. (22) and (27):

$$t_*^b = \frac{V}{\left(\sqrt{l/g}\right)^b (1+b)Al^a} \tag{28}$$

Using Equ (14), (28) becomes:

$$t_*^b = \frac{V}{\left(\sqrt{l/g}\right)^b (1+b)Kg^\beta l^a} \tag{29}$$

Using Equ. (12) and (13) the denominator in Equ. (29) becomes:

$$\left(\sqrt{l}\right)^b \left(\sqrt{g}\right)^{-b} (1+b)K\left(\sqrt{g}\right)^{1+b}\left(\sqrt{l}\right)^{1-b} \tag{30}$$

Simplifying (30):

$$(1+b)K\sqrt{gl} \tag{31}$$

Using (31) in the denominator of (29) yields: $t_*^b = \frac{V}{(1+b)K\sqrt{gl}} = \frac{1}{(1+b)} V_*$ (32)

From Equ. (32): $$t_* = \frac{1}{(1+b)^{1/b}} V_*^{1/b} \tag{33}$$

Using Equ. (19), (26) and (33): $$X_* = \frac{-b}{(1+b)} V_* \frac{1}{(1+b)^{1/b} K^{1/b}} V_*^{1/b} \tag{34}$$

Simplifying (34): $$X_* = \frac{-b}{(1+b)^{(b+1)/b} K^{1/b}} V_*^{(b+1)/b} \tag{35}$$

Setting: $$a = \frac{b+1}{b} \tag{36}$$

and: $$M = \frac{-b}{(1+b)^a K^{1/b}} \tag{37}$$

Substituting from Equ. (36) and (37) into Equ. (35): $X_* = MV_*^a$ (38)

Equation (38) converts fatigue curves into optimum fish swim distance curves.

5.0 ANALYSES OF FISH GROUP DATA

As indicated above, swimming performance curves based on individual fish species are limited for most species by insufficient data in the range of endurance time or swim distance.

Appendix 1 – Series D contains a collection of fatigue curves created with dimensionless variables from the processed data collection where the data are plotted by taxonomic classification. The concept of using taxonomic classifications to expand data grouping beyond the species level was based on similarities in performance that was observed between different fish species. Figure D-1a and D-1b plot all data by taxonomic order and family, respectively. These graphs indicate overall trends for the different taxonomic groups where higher or lower swimming performance levels correspond to the relative position on the graph. Figures D-2a to D-2x contain individual graphs for each family plotted by species and provide information about the overall fit and limitations of the data available for each family. As with the species groups, some family groups have adequate data and can be used to estimate performance for the collection of species in that family. It is important to note that the species that are used with the family groups are based on the existing data collection and do not reflect all of the possible species in the family. For example, the existing data for Clupeidae family is from a single genus Alosa (Alewife; American Shad; Herring) and the Clupeidae family has many more genus groups.

In Appendix 1 – Series E contains a collection of fatigue curves created with dimensionless variables from the processed data collection where the data are plotted by swimming mode. Swimming mode developed by Breder (1926) is a classification of different types of propulsive movements used by fish and was selected as a potential data grouping parameter. The swimming mode classification is not based on taxonomy but on similarities in swimming hydrodynamics.

Figure E-1 shows all data plotted by swimming mode where the focus was to highlight the most significant swimming modes (anguilliform; carangiform and subcarangiform) represented in the database. The swimming mode labeled "other" was used for species that used a swimming mode other than main three or a combination of swimming modes or where the swimming mode could not be defined for the species. The graph shows separation based on swimming mode, where points plot higher or lower based on the performance level. Many fish species are known to utilize various swimming modes based on the activity and the classification reflects the dominant swimming mode based on routine activities. Figures E-2a to E-2d present individual graphs for each swimming mode plotted by family and provide information about the overall fit and limitations of the data available for each swimming mode.

The trends by taxonomic and swimming mode groups were used to reorganize the data collection into six groups of species: Catfish and Sunfish; Eel; Herring (Clupeidae); Pike; Salmon and Walleye; and Sturgeon. A series of six graphs for each of the groups is presented in Appendix 1 – Series F which includes: swim speed in meters per second versus time; swim speed in body lengths per second versus time and dimensionless swim speed versus dimensionless time plotted by family. Dimensionless graphs, where data are plotted by test method and apparatus or fish length and temperature, were also created. The series of graphs are designed to illustrate how changing units improves the overall fit of the data points resulting in a more robust model and to summarize some of the key data parameters for each group.

Note that although statistics indicate significant correlations for all species as a single group (Appendix 1 – Series D Fig. D-1a; R^2= 0.598, RMS=0.425), separating species into groups improves the statistics. The Table A2a (Appendix 2) provides a summary of the regression results (least squares) for the dimensionless speed versus dimensionless time data. The table presents the regression results in a hierarchical order with each of six groups at the upper level and the underlying taxonomic groups in descending order from Order to species. The table provides an overview to the species that make up the different grouping levels and their corresponding regression values. In this table only relevant regression results were included for each group. For example if a particular species did not have enough data to produce a relevant regression the cells on the table were left blank.

The Table A2b presents the regression results for swimming speed in body lengths per second versus endurance time and is organized in the same way as Table A2a and can be used to compare the results with the dimensionless variables. In this table, the regressions were calculated for only selected groups and taxonomic levels which facilitate comparisons.

It should be noted that the data collection included three families from the order Perciformes and that these families were placed into different groups. The Centrarchidae family which includes sunfish, Smallmouth Bass and Largemouth Bass were placed in the Catfish and Sunfish Group and the family Moronidae (White Perch and Striped Bass) and Percidae (Walleye, White Perch and Yellow Perch) were placed in the Salmon and Walleye Group. This separation was based on finding the best fit in terms of how data were related in the various groups. There were also a few species that did not fit any of the taxonomic groups that made up the larger groups and these species were excluded rather than forcing them into a group where there was limited justification to include them.

The Pike Group had limited data in the higher swim speed range and it was not possible to produce a regression that defined performance in the 3 second to 30 minute range. However, because this is an important species for the Canadian Prairies and there was a real need for swimming performance data a process using existing data was used to derive a surrogate curve. The process used existing pike data to define the lower end of the performance curve and the intersection of the upper end of the regression lines from the Eel Group and the Salmon and Walleye Group were used to define the upper end (higher swimming speed) of the curve. Pike are known to be fast swimmers for short time periods and the assumption was made that the performance of pike at the upper end would be as good if not better than the strongest fastest swimming groups at the burst end of the performance curves. The Pike Group regression is based on the derived performance estimates.

The dimensionless endurance data for the six groups were replotted in Appendix 1 – Series G using Deming regressions calculations rather than least-squares. Deming regression analysis was used to address concerns regarding the fact that in some swimming performance methods the dependent variable is swimming speed and in others it is endurance time. When plotting data from an experiment where the results consist of independent and dependent variables, the independent variable is usually plotted on the x-axis and dependent variable on the y-axis. For fixed velocity tests, water velocity (swimming speed) is fixed and the time to fatigue is measured. For the increasing velocity tests, the critical velocity (swimming speed) is measured and is dependent on the time and velocity steps which are independent. For the data collection that was used in the regression analysis both swimming speed and endurance time could be dependent or independent variables depending on the test. The Deming method produces a regression equation where the result is not affected by which variable is defined as independent or dependent. Deming regressions were produced for dimensionless endurance data and for endurance data with swimming speed was in body lengths per second vs time (Appendix 2 - Tables A2c and A2d). The Deming regression results were very similar to the results produced with traditional least squares linear regressions.

The fatigue curves or speed-time data regressions for the various groups were converted to water velocity-swim distance curves using Equ. (16) and (19). Available data on direct measurements of swim distance may also be used to verify the estimated swim distance curves from speed-time data regressions.

Fatigue Equations for Grouped Data

Table 3a. Grouped data dimensionless fatigue regression equations.

Group	***U_* vs t_* Regression Equation***					
	k	*b*	*R^2*	*ChiSQ*	*Count*	*Comments*
Catfish and Sunfish Group	2.176	-0.202	0.64	59.5	1282	Limited data on burst range
Eel Group	3.722	-0.367	0.84	124.7	1747	Most comprehensive data sets
Herring Group	10.119	-0.402	0.90	7.4	592	Lack of prolonged data; b could be high
Salmon and Walleye Group	4.004	-0.250	0.70	1933.2	17085	Most comprehensive data sets
Sturgeon Group	0.756	-0.130	0.69	22.7	1008	Lack of burst data; *b* could be low
Pike Group (derived)	3.811	-0.329				All points in low prolonged range; lack of burst data; curve derived by assuming burst performance similar to Salmon and Walleye and Eel groups

Note: R^2 = correlation coefficient; ChiSQ = Chi-square statistic; Count = fish count

Table 3b. Grouped data dimensionless fatigue equations 75% and 95% prediction interval coefficients.

Group	***95% Prediction Interval***				***75% Prediction Interval***			
	Upper Boundary		Lower Boundary		Upper Boundary		Lower Boundary	
	k	*b*	*k*	*b*	*k*	*b*	*k*	*b*
Catfish and Sunfish Group	3.326	-0.202	1.424	-0.202	2.791	-0.202	1.696	-0.202
Eel Group	6.295	-0.367	2.201	-0.367	5.066	-0.367	2.735	-0.367
Herring Group	12.605	-0.402	8.123	-0.402	11.511	-0.402	8.895	-0.402
Salmon and Walleye Group	7.744	-0.25	2.07	-0.25	5.897	-0.25	2.719	-0.25
Sturgeon Group	1.018	-0.13	0.562	-0.13	0.9	-0.13	0.635	-0.13
Pike Group (derived)	5.962	-0.329	2.437	-0.329	4.950	-0.329	2.935	-0.329

Distance Equations Grouped Data

Table 4. Grouped data dimensionless swim distance equations and 75% and 95% prediction interval coefficients derived from fatigue regressions.

Group	$X_\cdot$ vs $V_\cdot$		***95% Prediction Interval***				***75% Prediction Interval***			
			Upper		*Lower*		*Upper*		*Lower*	
	M	*a*	*M*	*a*	*M*	*a*	*M*	*a*	*M*	*a*
Catfish and Sunfish Group	3.892	-3.953	31.668	-3.948	0.476	-3.958	13.321	-3.95	1.136	-3.956
Eel Group	5.982	-1.723	25.017	-1.723	1.43	-1.724	13.85	-1.723	2.584	-1.723
Herring Group	59.34	-1.489	102.933	-1.491	34.239	-1.487	81.967	-1.490	42.973	-1.488
Salmon and Walleye Group	26.919	-2.994	374.991	-2.993	1.932	-2.994	126.33	-2.994	5.736	-2.994
Sturgeon Group	0.006	-6.669	0.059	-6.668	0.001	-6.669	0.023	-6.668	0.002	-6.669
Pike Group (derived)	8.512	-2.040	33.161	-2.040	2.185	-2.040	18.839	-2.040	3.846	-2.040

6.0 DESIGN CURVES

A collection of swim speed vs endurance time curves (Appendix 1 – Series H) and swim distance vs water velocity curves (Appendix 1 – Series J), useful in designing fish passage systems were created for selected fish lengths for each of the 6 data groups. These curves were created using the dimensionless equations presented in Appendix 2 - Table A2d. The graphs include mean regression lines, which indicates average performance or where 50% of the fish would be expected to achieve the corresponding time or distances (half fall above the line and half below). The graphs also include lines for upper and lower estimates of swim time and distance based on prediction intervals of 75% and 95%. Prediction Intervals (PI) sometimes known as probability intervals, are different from confidence intervals.

Examples of swimming endurance and distance estimates for species in the Salmon and Walleye group for a fish length of 250 mm are presented in Figure 1A and 1B, respectively. Figure 1A, uses the swimming speed of 1 m/s to illustrate the range of corresponding endurance times for species in this group. For example, Figure 1A could be used to estimate the performance of a 25 cm Brook Trout (*Salvelinus fontinalis*) since this species is part of the Salmon and Walleye group. On average, a 25 cm Brook Trout would be expected to swim for 260 seconds or 4.3 minutes (i.e., 50% of these fish are estimated to be capable of achieving this endurance time). The lower 95% prediction interval indicates that 95% of (predicted) data would fall above this line which means that 95% of fish in this group would be able to swim for 18 seconds or longer at 1 m/s. The upper 95% prediction interval indicates that 95% of (predicted) data would fall below this line which means that only 5% of fish in this group would be able to swim longer than the corresponding time. However for this group the 1 m/s swimming speed does not intersect the upper 95% prediction interval because these graphs are based on endurance times of 3 seconds to 30 minutes and in this case the conclusion would be that 5% of fish could swim for more than 30 minutes. The upper and lower 75% prediction intervals would correspond to 25% and 75% of the predicted data falling above the respective lines. With 75% of fish swimming at 55 seconds or more and 25% of fish swimming for more than 1100 seconds (18 minutes). Note, the large difference between endurance estimates based on the average line vs the upper or lower estimates.

Figure 1B uses a water velocity of 1 m/s to illustrate the range of corresponding swimming distances for species in this group. As with the endurance example, there is a large difference between swim distances based on the average line vs the upper or lower estimates. In this example, using the same 25 cm Brook Trout (*Salvelinus fontinalis*) moving against a 1 m/s water velocity, on average it is expected to navigate a distance of 25 m (i.e., 50% of these fish are estimated to be capable of achieving this distance). The figure also indicates that 95% of these fish could swim a distance of 2 m or more, 75% a distance of 6 m or more, 25% a distance of more than 120 m, and 5% a distance of more than 320 m against a water velocity of 1 m/s.

Fish must swim faster than the water velocity they are facing in order to move forward and the distance curves were derived based on optimizing the swim speed to maximize distance. For the Salmon and Walleye group the optimization resulted in a swimming speed that was approximately 33% faster than the water velocity. Species in this group would use a swimming speed of 1.33 m/s when facing a water velocity of 1 m/s.

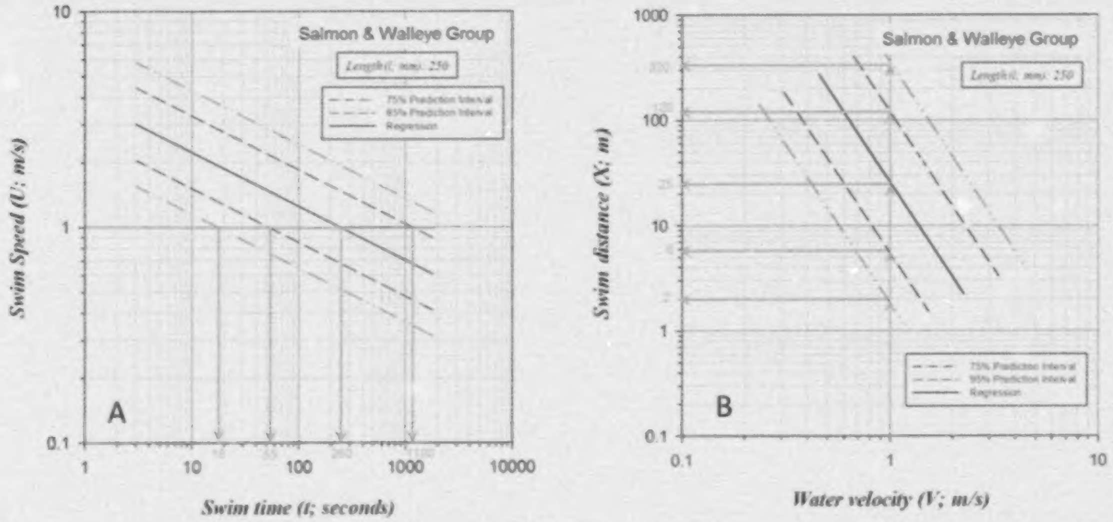

Figure 5. Example of swim endurance and distance estimates for Salmon and Walleye groups for fish length of 250 mm, in Figure A endurance times corresponding to a swimming speed of 1 m/s are shown and in Figure B swim distances corresponding a water velocity of 1 m/s are shown.

The range of estimated swim endurance and distance allow the level of protection needed for a particular fish population to be considered in specific projects.

7.0 DISCUSSION

Limitations of Swim Tests

- The lack of standardized test methods for swimming performance means that each study and corresponding data collection has unique characteristics in how performance is measured and how the data are interpreted. All swim tests have limitations and it is important to recognize and understand how these limitations are reflected in the swimming performance that is measured.
- Performance estimates from volitional swim tests focus on fish that attempt passage by moving out of the holding area and into the test channel. In some studies, a significant number of fish did not stage an attempt at passage (Haro et al. 2004, Peake 2008b). Swimming ability of the fish that choose not to leave the staging area is unknown. In forced tests, all fish in the test population are tested with very few exceptions (exclusion may include ill or injured fish). Forced swim tests usually measure performance in a greater percentage of the test population which may account for more variation in the performance compared to volitional testing.
- In many studies, information and measurements related to the hydraulics of the flow field where fish are tested is not reported or is limited which makes it difficult in some cases to interpret the data that was produced. The objective in most swim tests is to provide fish with a uniform flow field, however this is not always possible, particularly when testing fish in high water velocities. Generating high water velocities in an open channel can produce waves or hydraulic jumps resulting in a variation in velocity along the channel which if not accounted for can impact performance estimates. Hydraulic jumps occur when faster water encounters slower water resulting in the release of energy and

a change in velocity. Turbulence is also another hydraulic phenomenon, particularly in open channels which may influence performance estimates. Solid blocking effects can occur in swim tunnels when the size of the fish is large relative to the cross-section of the test apparatus and hydraulics are impacted, correction factors have been used in some studies to adjust the performance measurement. The length of fish tunnels has also been raised as a concern in terms of limiting performance by not providing adequate space for fish to fully engage in their preferred swimming movement pattern.

- Different thresholds have been used to define the point when fish fatigue in swim tunnels. For example, Jain and Farrell (2003) defined exhaustion as the point at which fish failed to swim away from the electrified rear grid after 20 seconds of contact. For Tudorache et al. (2007) fatigue was determined using a photoreceptor-based automated system measuring fish contact with a metal grid delineating the downstream end of the flume. Fatigue was defined as occurring when a fish touched the grid three times in 3 seconds or less. Differences in how fatigue is defined can influence performance measurements; for example, overly sensitive methods may show premature failure when incidental contact occurs with an automated system.
- Fish have the ability to detect and utilize zones of lower velocity (Figure 6). Studies of fish movement through culverts have shown that small fish can take advantage of the low velocity boundary layer along the culvert wall to achieve passage where hydraulic conditions permit (Light et al. (2013); Peterson et al (2013); Powers et al (1997). Misrepresentation of swimming performance can occur when passage success is reported based on average velocity when in fact fish are using zones of lower velocity. The size of the fish relative to low velocity zone is a factor in the ability to exploit these areas during passage.

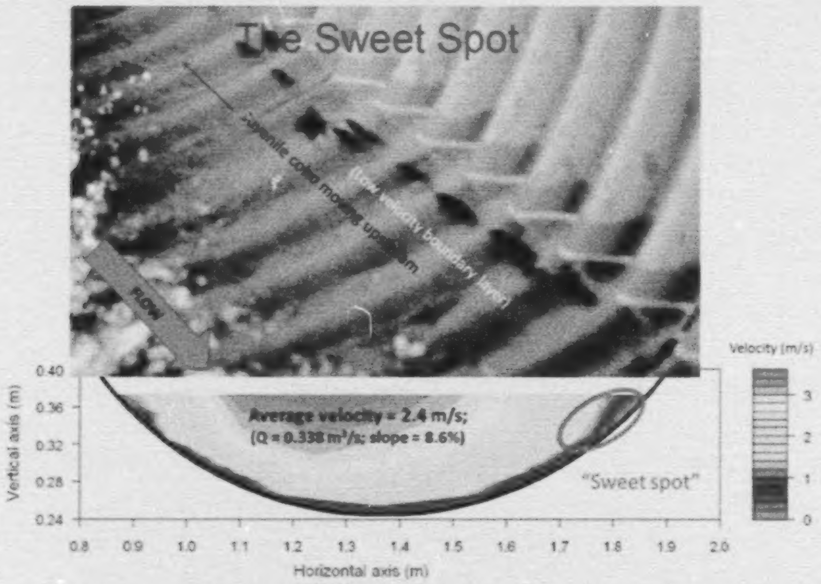

Figure 5. Juvenile Coho Salmon (Oncorhynchus kisutch) migrating through a culvert; note the size and location of the fish relative to the culvert corrugations, the lower velocities in this zone are used to achieve passage (Powers et al. 1997). The cross-sectional velocity profile (Light et al (2013)) shows the "sweet spot" or low velocity boundary layer used by wild Cutthroat Trout (Oncorhynchus clarkia) when the average velocity in the culvert was 2.4 m/s. In terms of swimming performance, it is important to note that the velocity in zone that was used by the Cutthroat Trout to achieve passage was 1 m/s or less.

Behavioral and Physiological Performance Limits

Concerns have been raised in the literature regarding swimming performance measurements generated from swim tunnels and the increasing velocity test in particular, due to confinement which may limit swim movements or gaits' resulting in a premature stoppage of swimming before exhaustion is reached (Peake and Farrell 2006, Castro-Santos 2005, Tudorache et al. 2007).

Peake and Farrell (2006) concluded that "fatigue is a behavioural decision made at (or near) the gait transition swimming speed, in an effort to avoid activity that, by virtue of the limited space in a typical respirometer, is energetically inefficient and biomechanically difficult". This conclusion was based on a comparison of the anaerobic fuel stores (muscle glycogen, muscle lactate and plasma lactate levels) in Smallmouth Bass (*Micropterus dolomieu*) that were chased to exhaustion and tested to fatigue using the Ucrit test.

Reidy et al. (1995) also found post-exercise oxygen consumption rates were significantly higher in groups of Atlantic Cod (*Gadus morhua*) that were tested to exhaustion using the chase and Uburst (anaerobic test) protocols compared to the Ucrit protocol (5 cm/s velocity increments every 30 min) and concluded that post-exercise MO2 rates were dependent upon how exhaustion is induced.

The distinction between behavioral and physiological limits in swimming capacity is important in understanding and applying the data that is generated from the various types of swimming performance tests. It is important to examine the Ucrit test (test of concern) to see where measurements from this test fit on the swim speed versus time performance curve when drawing conclusions about possible performance limitations. The challenging part of fitting the data from this test on a fatigue curve is defining an endurance time for the critical swimming speed (Ucrit) that is measured. In this test, Ucrit is measured by subjecting a fish to a series time and velocity steps where velocity is increased during each time step until the fish stops swimming. The interpretation of Ucrit is further complicated by the variety of time steps and velocity increments that have been used and reported in the literature.

The critical swimming speed (Ucrit) was first introduced by Brett (1964) in conjunction with the increasing velocity test which he developed to study oxygen consumption rates in young Sockeye Salmon (*Oncorhynchus nerka*) at various swimming speeds. In his test, 75 minutes was used for each velocity step. In an effort to standardize the results for comparison on a uniform time basis with earlier steady performance data, he conceived the critical swimming speed where speed at failure was adjusted to account for the proportion of time that the fish swam during the final step. Brett's example "*if a fish having swum at 2.0 feet/sec successfully was required to swim at 2.3 feet/sec and fatigued in 20 min, its critical swimming speed, was calculated as: 2.0 + (20/60 x 0.3) feet/sec = 2.1 feet/sec*". Brett used 60 minutes as the standard in his calculation, which he referred to as "60-minute sustained speeds". Brett (1982), made the clarification that "*the term "maximum 60-minute sustained speed" is actually a misnomer, since sustained speeds are those of longer duration (theoretically to infinity). It refers instead to the prolonged swimming speed corresponding to the 60-minute time interval. Critical speeds derived by Brett (1964, 1967) happened to be those for 60-min duration, the final increment of velocity being calculated as the maximum that could be sustained for such an interval (hence the misnomer).*" Brett (1964) acknowledged that his Ucrit calculation was arbitrary and he created a swimming speed versus time fatigue curve using fixed velocity test data to compare with the critical swimming speed. In hindsight, some of early assumptions and conclusions made by Brett in this initial study where 60 minutes was used as a standard for the 75 minute time step were somewhat limited; however this was the first time this test was ever used. Despite the limitations, the relationship between the time step and critical swimming speed was introduced and the data showed that the time step was a reasonable estimate of endurance time.

Farlinger and Beamish (1977) evaluated the effects of time (5, 10, 30, and 60 minutes) and velocity (2.5, 5, 10, and 20 cm/s) increments on the critical swimming speed of Largemouth Bass (*Micropterus salmoides*) and found overall critical performance varied almost twofold with increments of velocity and time from a minimum of 30 cm/s to a maximum of 50 cm/s. The highest and lowest critical swimming speeds occurred for time intervals of 5 and 60 minutes respectively and when critical speed was plotted against the time interval the shape of the curves resembled fixed velocity test fatigue curves. Results from this experiment show that the critical swimming speed is not a fixed value but rather a function of the time and velocity intervals.

Jones et al. (1973) used the Ucrit test with ten minute time steps as a measure of the maximum swimming speed that could be maintained for 10 minutes for several Mackenzie River fish species. In preliminary testing, critical swimming speeds were found to be similar when using time increments of 10 and 20 minutes, which is consistent with data from fixed velocity fatigue curves where relatively small differences in swimming speed correspond to larger time differences in this range of the performance curve.

Figure 7 shows endurance curves for juvenile Shortnose Sturgeon from Deslauriers and Kieffer (2012) where the data points were from fixed velocity tests with an upper time limit to 270 minutes. The critical swimming speed was also measured using 20 minute time steps and has been superimposed on the endurance plot (red dot) and shows a relative close fit with prolonged data. The authors used two curves to define sustained and prolonged swimming speeds (black lines) for the fixed velocity test data. The data points for 270 minute reflect the upper time limit of the test and actual fatigue times for these velocities would greater particularly at the lower velocities and the sustained regression line would have steeper slope that was is shown in the figure.

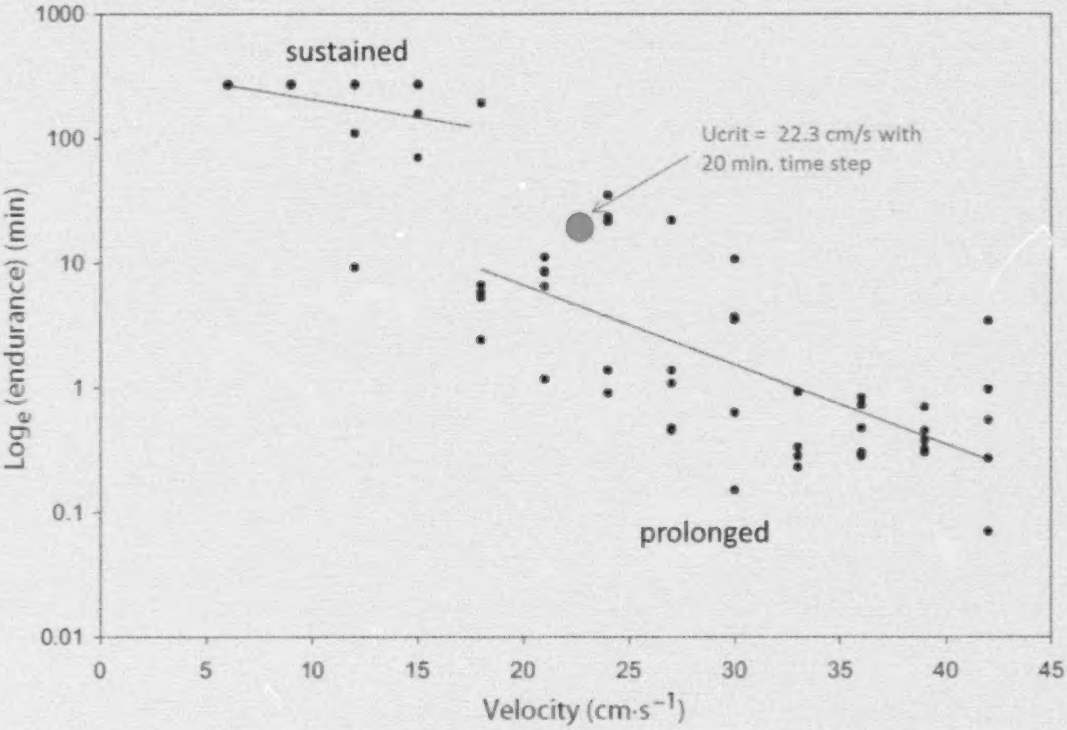

Figure 7. Endurance curve for juvenile Shortnose Sturgeon (Acipenser brevirostrum) from Deslauriers and Kieffer (2012). Data points (black dots) are from fixed velocity tests and data from the critical swimming speed test (based on a 20 minute time step) was added (large red dot) and shows the Ucrit point using 20 minutes as endurance time, falls relatively close to the 20 minute endurance data. The graph also highlights the wide range in endurance times for most velocities. The test time limit was 270 minutes and corresponding endurance times at these velocities would be greater than what is shown in the graph.

Furthermore, work by Farrell (2008) with Smallmouth Bass *Micropterus dolomieu* Lacepede also points to fish being fatigued rather than exhausted after Ucrit tests, and additionally provides a mechanistic explanation why this might be so, as well as a warning about the ecological application of Ucrit data. Voluntary raceway ascents with Smallmouth Bass resulted in speeds considerably greater than Ucrit that could be maintained for at least 2 min and the accumulation of plasma lactate was directly proportional to the voluntary raceway swimming speed (Peake and Farrell, 2004, 2005). In addition, when oxygen uptake, plasma lactate, muscle lactate and muscle glycogen were measured in Smallmouth Bass chased to exhaustion and compared with fish forced to swim to Ucrit in a respirometer, it was clear that Ucrit swimming resulted in a fatigued state rather than an exhausted state. Evidence was also presented to suggest that the lower Ucrit speed was related to an inability to attain a ground speed when the fish tried to shift 'gears' in the swim tunnel (unlike raceway swimming) and rely entirely on white muscle for locomotion. Thus, another contributor to Umax being greater than Ucrit might be the possibility of constant acceleration providing fish with the sensation of achieving ground speed in a swim tunnel and allowing fish to make a better transition to glycolytically powered locomotion and to more fully exploit its glycolytic potential before ceasing to swim.

Higher energy depletion in fish that were chased to exhaustion compared to Ucrit testing may be related to survival instincts that trigger a higher response by maximizing swimming effort and energy usage when chased and survival is at stake. Stress is also known to reduce energy levels in fish and this may be a consequence of the chasing test. Maximum swimming efforts are physiologically costly and a recovery period is required where fish are at risk and circumstances that result in complete exhaustion are usually avoided. The performance limit that is reached during testing may be behavioural or physiological depending on the nature of the test; however these responses may reflect natural behaviors where swimming to the point of exhaustion is only used when absolutely needed and routine swimming activities are aborted when a species specific energy or effort threshold is reached.

The discussion of performance limitations related to swim tunnel tests needs to be quantified in terms of significance and related to the objective of the test. A number of studies have shown that fish do not swim to exhaustion when tested in swim tunnels and open channel volitional tests. If the objective is to measure performance based on the point of total physical exhaustion, the swim tunnel and open channel tests will likely underestimate performance. However, if the objective is to measure performance based on natural behaviour for routine activities, data from these tests provide reasonable estimates. Design criteria for fish passage and protection that is based on fish swimming to the point of total exhaustion is clearly not a realistic objective for fish.

Tudorache et al (2010) measured critical swimming speeds (20 minute time and 5 cm/s velocity steps) in Brook Trout (*Salvelinus fontinalis*) (fork length (mean ± S.D.) 12.2 ± 0.1 cm) using long (75 cm) and short (35 cm) flumes with long (10 second) and short (3 second) impingement times. Impingement refers to the time duration that fish are pinned on the rear grid before the test was stopped. Critical swimming speed for long and short flumes with 10 second impingement time were 61.70 ± 4·07 and 56.87 ± 2·51 cm/s respectively and for the 3 second impingement time were 64.75 ± 4·23 and 55.90 ± 4·82 cm/s respectively. Critical swimming speeds were 9% and 16% percent higher for the longer flumes for the 10 and 3 second impingement times, respectively. Considering the standard deviation for these tests, such a difference in critical swimming speeds is relatively minor and is in the range of biological variability. When using swimming performance data it is important to apply the appropriate perspective, differences that are significant when viewing data over a very narrow window can become insignificant when the same data are viewed using a larger window. Results from this test found that 12 cm Brook Trout had swimming speeds that ranged from 0.56 to 0.65 m/s for the endurance time of 20 minutes and the maximum difference in swimming speeds was 0.09 m/s or 9 cm/s for the longer flume with 3 second impingement which is relatively small when put in context of the overall range of Brook Trout swimming speeds.

Further research is needed related to the burst-and-coast swimming gait in terms how is it triggered and where it fits in the range of swimming gaits employed by fishes. Experimental evidence from studies have shown that burst-and-coast propulsive movements are generated by axial white fibres to support and prolong swimming when current velocity gets stronger and oxygen consumption approaches its upper limit (Dutil et al. 2007). The burst-and-coast swimming gait has also been observed in fish that were tested in tilted raceway (channel) where water velocities increase with distance upstream. In these tests, fish were found to switch from steady swimming to burst and coast when water velocities were similar to those in swim tunnel. Castro-Santos (2005) did not observe any burst-and-coast swimming gaits for the six different fish species tested in open channel flume sprint tests. Webb (1997) in defining the pattern of gait recruitment with performance level noted that the highest swimming speeds (sprints) use steady swimming that is fully anaerobic. In the hierarchy of body and caudal fin swimming gaits, Webb (1997) places burst and coast swimming between cruising (sustainable continuous swimming at low speeds) and sprints (rapidly fatiguing continuous swimming at high speeds).

The recruitment of the burst-and-coast gait may be more complex than swimming speed alone and may include a time factor that is key to when it is triggered. The burst-and-coast gait occurs in the upper performance range where performance is constrained by both swim speed and time. A key question is how much does the potential restriction of burst-and-coast swimming affect the critical swimming speed and is it significant enough to affect the performance estimates from this test.

8.0 CONCLUSIONS AND RECOMMENDATIONS

1. An extensive database on fish swimming performance was generated from the literature. This effort utilized data from a large number of studies since 1990 when the first and much smaller data base was produced.
2. Extensive data scrutiny and analyses of the available data were performed. Large variability in swimming performance is indicated.
3. Fatigue curves or fish speed-time regressions were developed for just a few individual species, since sufficient data are lacking. There are insufficient data for most species and significant regressions are not available for these fish.
4. Dimensionless variables allowed more global data analyses for groups of fish species and heightened the ability to use limited data sets.
5. Significant speed-time regressions (fatigue curves) were developed for five fish groups. The large variability in the data is reflected in these curves.
6. Swim distance – water velocity curves were derived from each of the five groups.
7. Derived swim distance estimates where reasonable when compared with available swim distance data.
8. Ranges of swim distance estimates allow the level of protection needed for a particular fish population to be considered in specific projects.
9. It is recommended that the newly derived swim performance curves replace those developed in the early 1990s.

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APPENDIX 1

Graph Series Collection Representing Data, Analysis and Results

APPENDIX 1–SERIES A

Preprocessed Endurance Data

Swim Speed (*U/l; body lengths/second*) vs Time-to-Fatigue (*t; seconds*)

Plotted by Species and Reference (131 graphs)

- The graphs in this series correspond to preprocessed endurance data that were collected from the literature. Swimming speed and time-to-fatigue data are plotted using traditional fatigue curve format with swimming speed in body lengths per second on the x-axis and time-to-fatigue in seconds on the y-axis in logarithmic scale. Data are plotted by species (scientific and common name) and reference (data source). Species such as *Oncorhynchus mykiss* with two different common names, Rainbow Trout for the freshwater form and Steelhead Trout for the anadromous (oceangoing) form are presented in separate graphs.
- Preprocessed data are used to describe performance data as it was originally reported in the literature. This data includes a mixture of raw and processed data where raw data are performance measurements for individual fish and processed data are the average performance for a group of fish. Processed or grouped data are often the only results reported in the literature and are used to describe the performance of related groups of fish that were tested individually.
- The data collection process also included digitizing data from graphs in publications to capture individual data points and to capture other data that were not provided as actual numbers in the reference text. Data formatting included converting measured values to common units (meters and seconds).
- Each graph in this series includes a corresponding summary table that provides information (mean, minimum, maximum, range and count) for key variables: fish length; temperature; swim speed; and endurance time. Endurance time (time-to-fatigue) is reported for the different test method as fixed and increasing velocity test. Record count is the number of measurements or data points in the graph and fish count is the corresponding number of fish. Some data points (records) are based on measurements from a number of fish.
- Plots in this series reflect the underlying data that were used in the derivation of the grouped design curves that were developed to estimate swimming performance. A more extensive data collection was initially assembled which included marine species; however, as the project evolved and the focus was refined based on priorities and work load capacity, marine species were excluded from further analysis. Data in these plots were screened based on endurance times of 150 minutes (9000 seconds) or less. The database does include endurance times greater than 150 minutes and the screening was mainly used to improve the aesthetics of the graphs in terms of readability.
- These plots illustrate the data gaps that exist for many of the species which is a limiting factor in the use of the species specific fatigue curves, however for a few species reasonable fatigue curves are available.

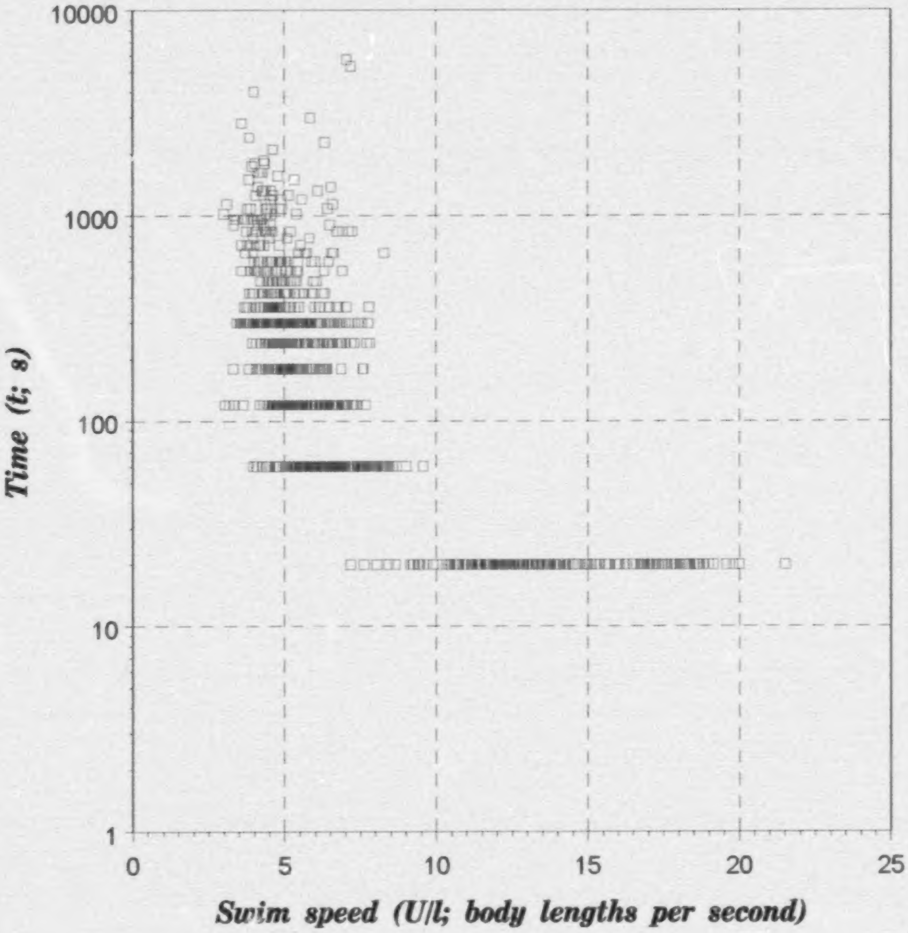


Figure A-001. Preprocessed data for Abramis brama *(Bream): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Clough et al. (2003).*

Table A-001. Swim speed data summary. Fish count 1180, record count 1180.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.79	0.009	0.06	0.111	0.051	51
T (C)	12.3	4.9	5.6	23	17.4	104
U (m/s)*	0.559	0.281	0.226	1.57	1.344	130
t_e (s)	301	421	60	5760	5700	37
$t_{\Delta t}$ (s)**	20	0	20	20	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

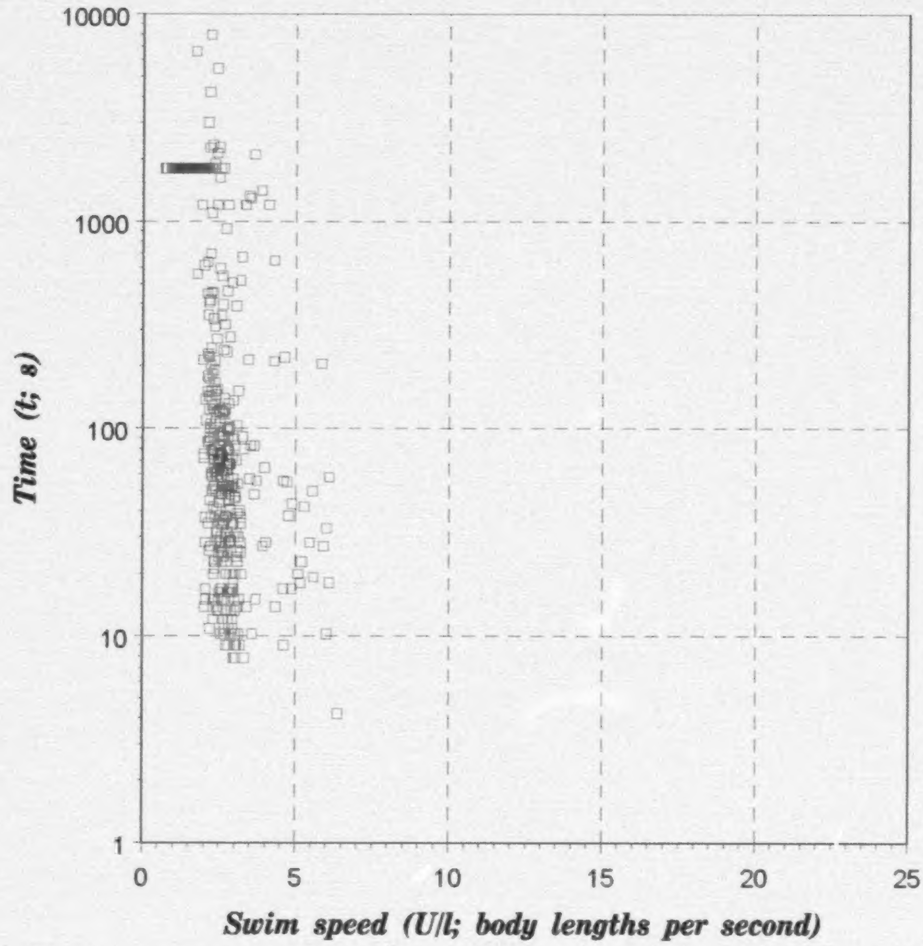


Figure A-002. Preprocessed data for Acipenser brevirostrum *(Shortnose Sturgeon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Deslauriers and Kieffer (2011).*

Table A-002. Swim speed data summary. Fish count 675, record count 675.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.162	0.035	0.062	0.239	0.177	114
T (C)	15	6.2	5	25	20	5
U (m/s)*	0.355	0.072	0.12	0.475	0.355	211
t_e (s)	236	783	4	7921	7917	168
$t_{\Delta t}$ (s)**	1786	92	1200	1800	600	2

* U=critical velocity (U_{crit})

** t=time step (Δt)

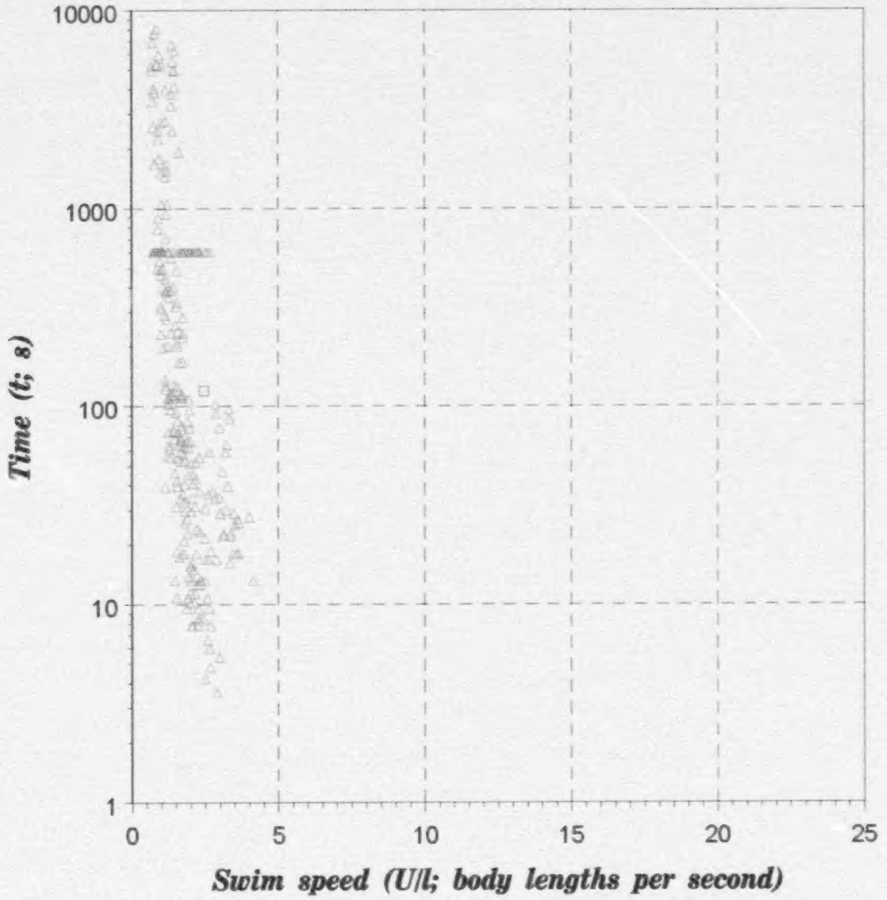


Figure A-003. Preprocessed data for Acipenser fulvescens *(Lake Sturgeon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Webb (1986); red triangles are data from Peake et al. (1995).*

Table A-003. Swim speed data summary. Fish count 307, record count 298.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.374	0.245	0.12	1.32	1.2	57
T (C)	13.2	4.9	7	21	14	4
U (m/s)*	0.57	0.289	0.2	1.8	1.6	53
t_e (s)	701	1567	4	8040	8036	168
$t_{\Delta t}$ (s)**	538	162	120	600	480	2

* U=critical velocity (U_{crit})
** t=time step (Δt)

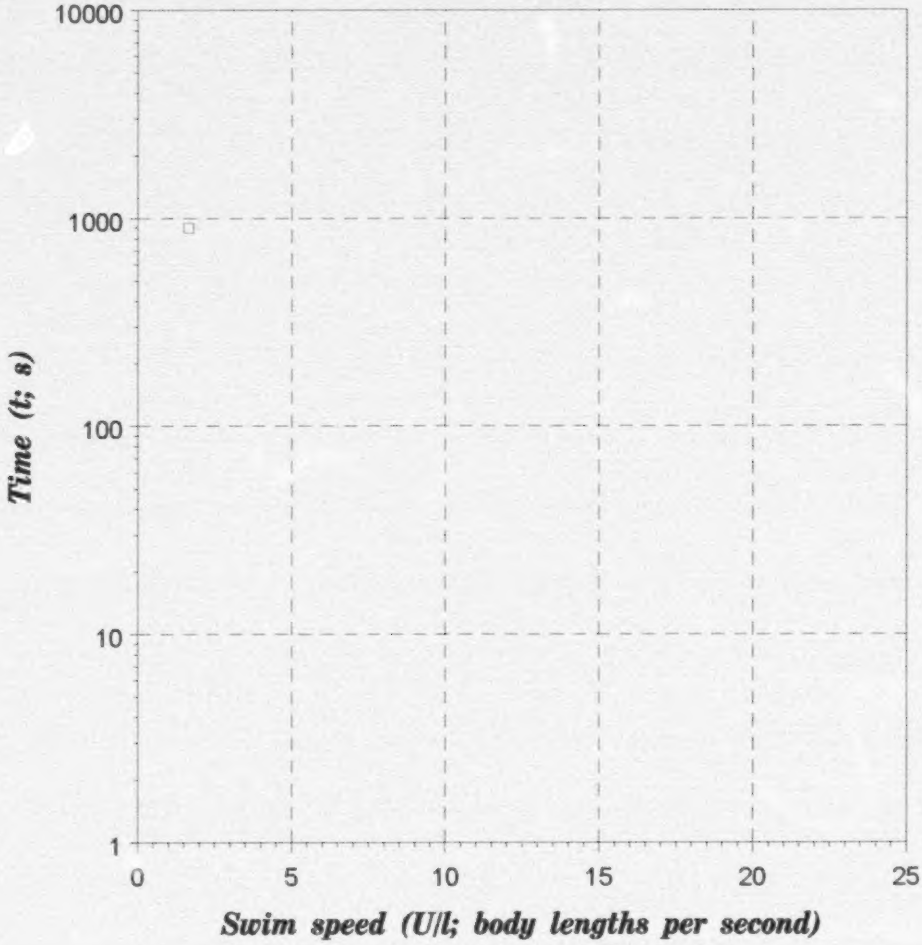


Figure A-004. Preprocessed data for Acipenser transmontanus *(White Surgeon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Counhihan and Frost (1999).*

Table A-004. Swim speed data summary. Fish count 14, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.342	0	0.342	0.342	0	1
T (C)	12	0	12	12	0	1
U (m/s)*	0.564	0	0.564	0.564	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	900	0	900	900	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

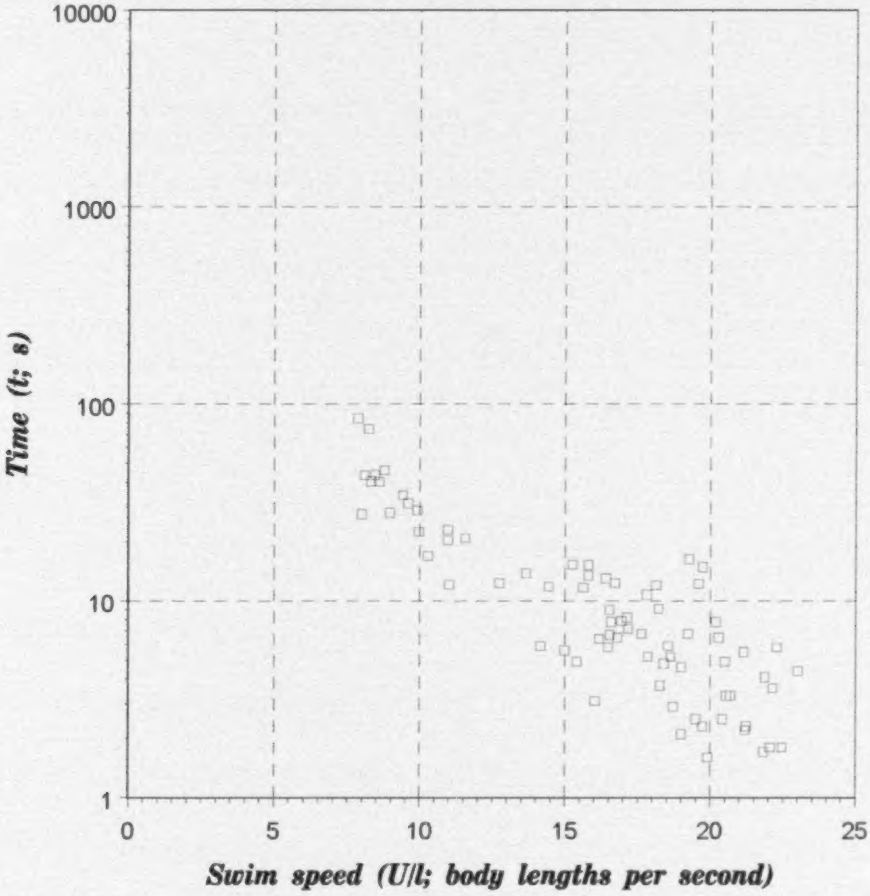


Figure A-005. Preprocessed data for Alosa aestivalis *(Blueback Herring): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Castro-Santos (2005).*

Table A-005. Swim speed data summary. Fish count 75, Record count 75.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.219	0	0.219	0.219	0	1
T (C)	16.9	0	16.9	16.9	0	1
U (m/s)*	3.548	0.976	1.72	5.04	3.32	70
t_e (s)	14	16	2	85	83	63
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

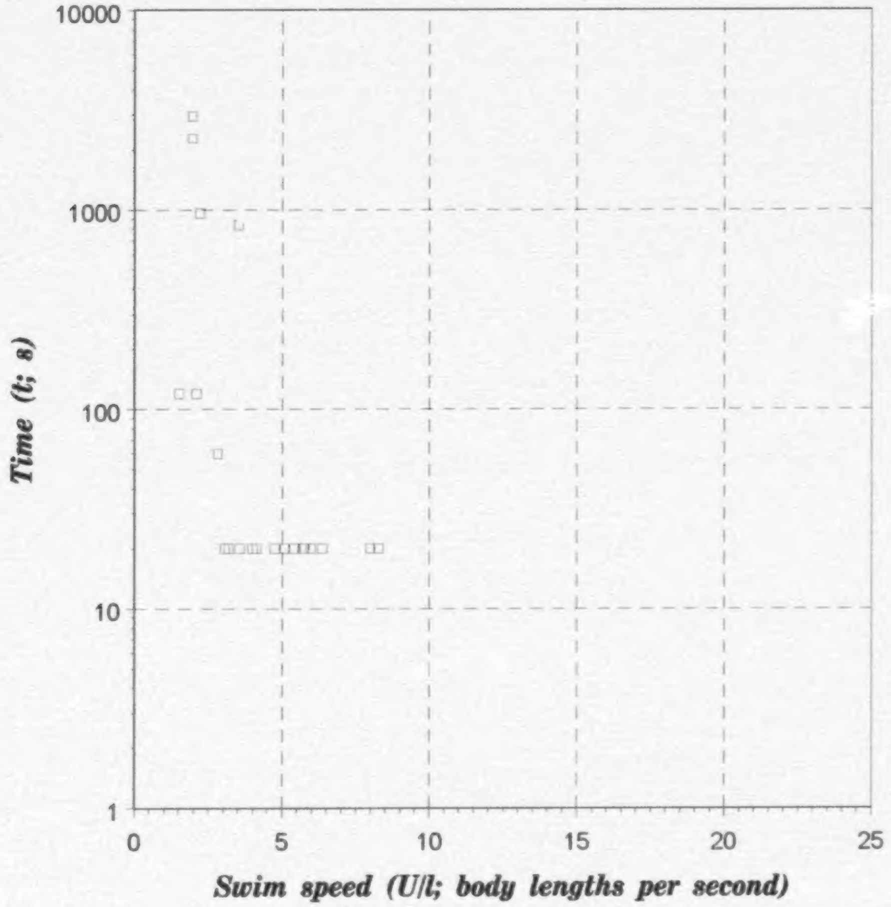


Figure A-006. Preprocessed data for Alosa fallax *(Twaite Shad): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Clough et al. (2004).*

Table A-006. Swim speed data summary. Fish count 21, record count 21.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.336	0.043	0.22	0.395	0.175	12
T (C)	18.7	2.8	12.8	21.5	8.7	16
U (m/s)*	1.398	0.603	0.578	2.515	1.937	18
t_e (s)	1046	1144	60	2940	2880	6
$t_{\Delta t}$ (s)**	20	0	20	20	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

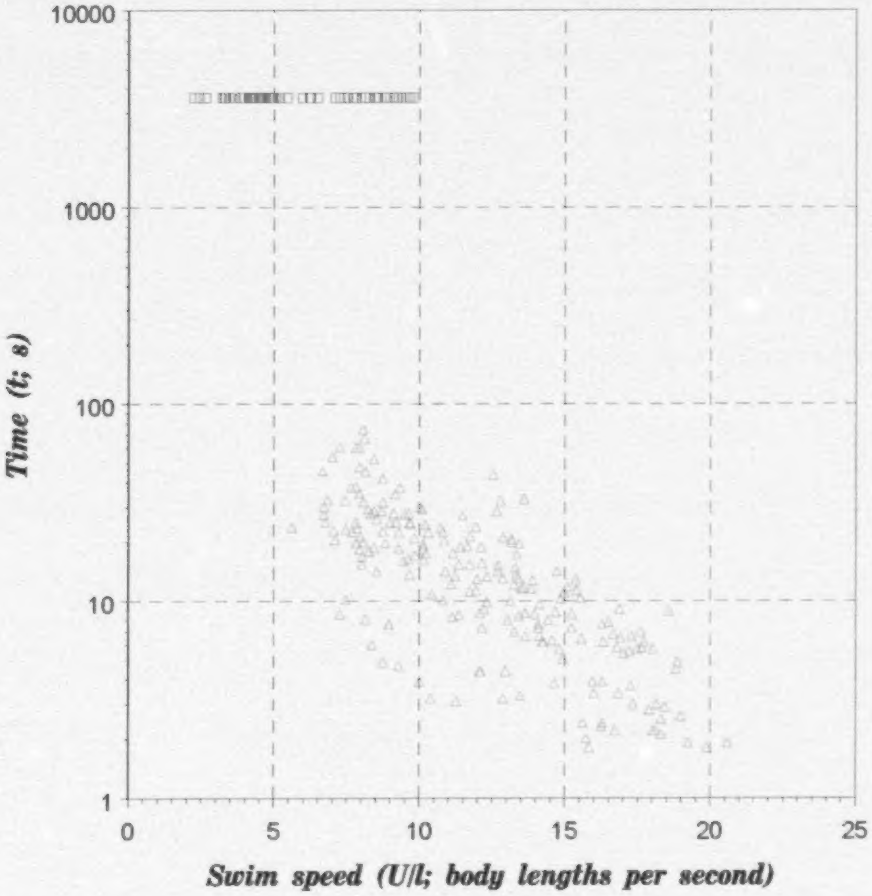


Figure A-007. Preprocessed data for Alosa pseudoharengus *(Alewife): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Griffiths (1979); red triangles are data from Castro-Santos (2005).*

Table A-007. Swim speed data summary. Fish count 265, record count 265.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.205	0.062	0.046	0.237	0.191	35
T (C)	10.3	0.2	10	10.4	0.4	2
U (m/s)*	2.339	1.251	0.268	4.88	4.612	194
t_e (s)	16	13	2	74	73	150
$t_{\Delta t}$ (s)**	3600	0	3600	3600	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

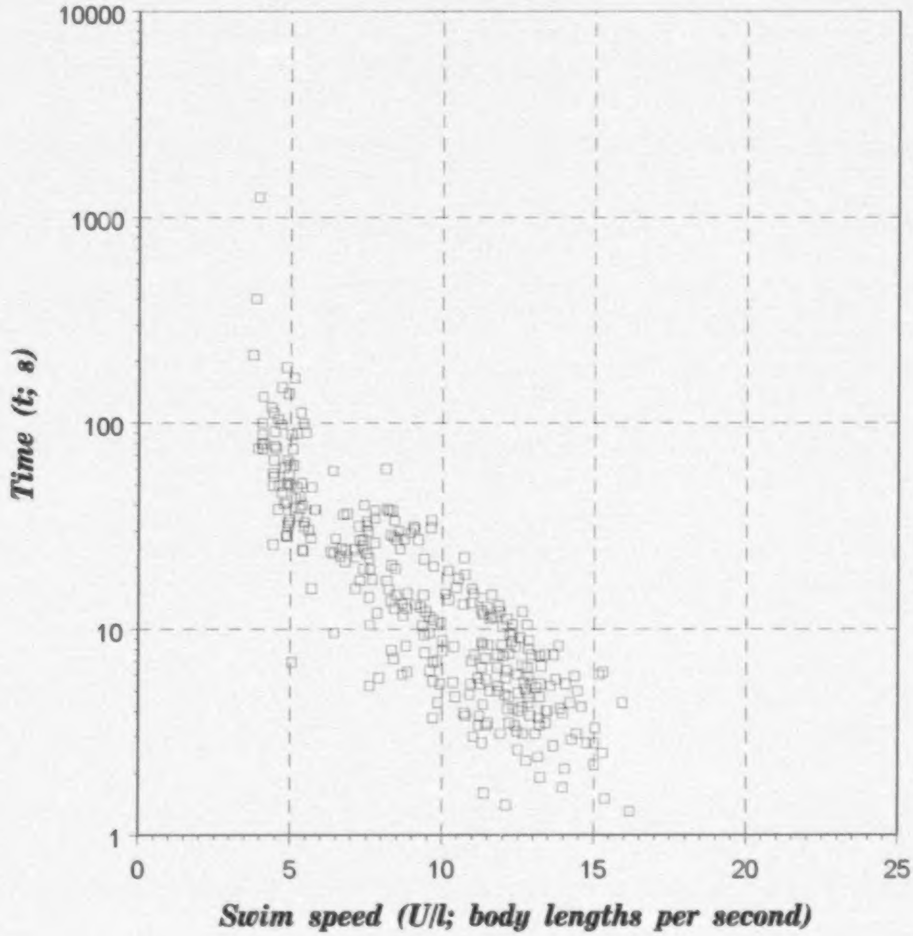


Figure A-008. Preprocessed data for Alosa sapidissima *(American Shad): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Castro-Santos (2005).*

Table A-008. Swim speed data summary. Fish count 294, record count 294.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.418	0	0.418	0.418	0	1
T (C)	18.3	0	18.3	18.3	0	1
U (m/s)*	3.945	1.363	1.57	6.76	5.19	217
t_e (s)	30	81	1	1252	1251	204
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

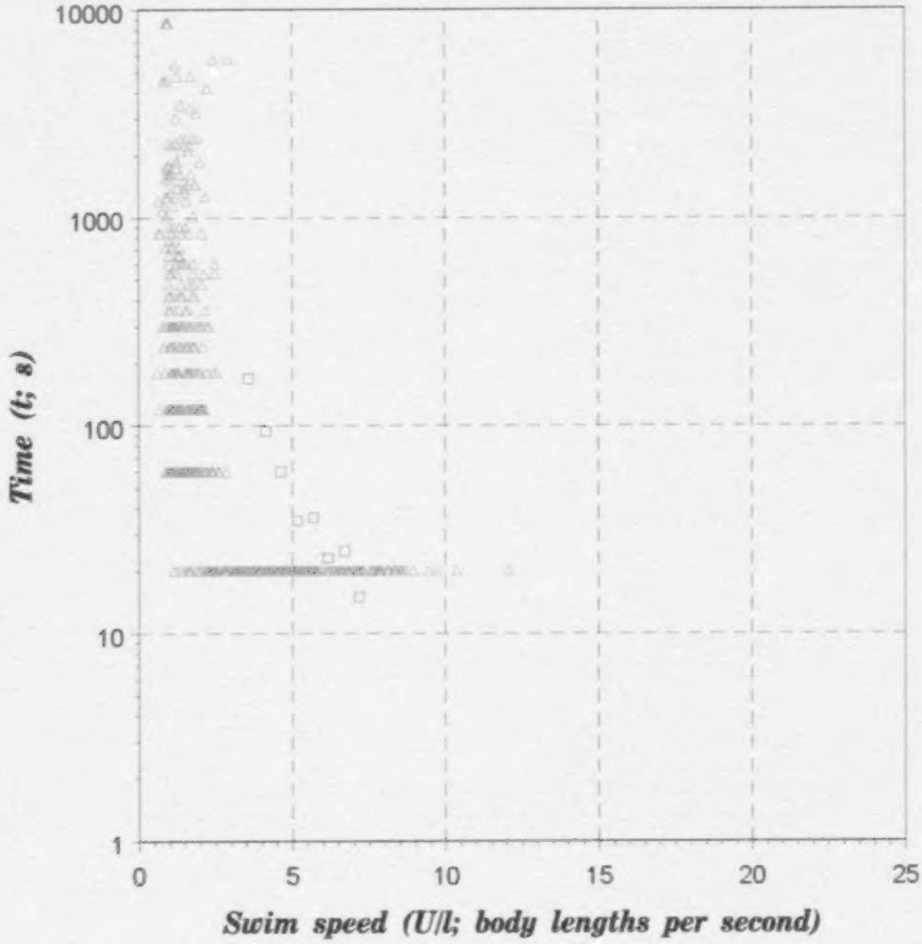


Figure A-009. Preprocessed data for Anguilla anguilla *(European Eel): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from McCleeve (1980); red triangles are data from Clough et al. (2003).*

Table A-009. Swim speed data summary. Fish count 708, record count 636.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.259	0.155	0.072	0.83	0.758	264
T (C)	15.4	3.7	10	23.5	13.5	85
U (m/s)*	0.71	0.46	0.136	2.26	2.124	169
t_e (s)	559	1190	15	8640	8625	50
$t_{\Delta t}$ (s)**	20	0	20	20	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

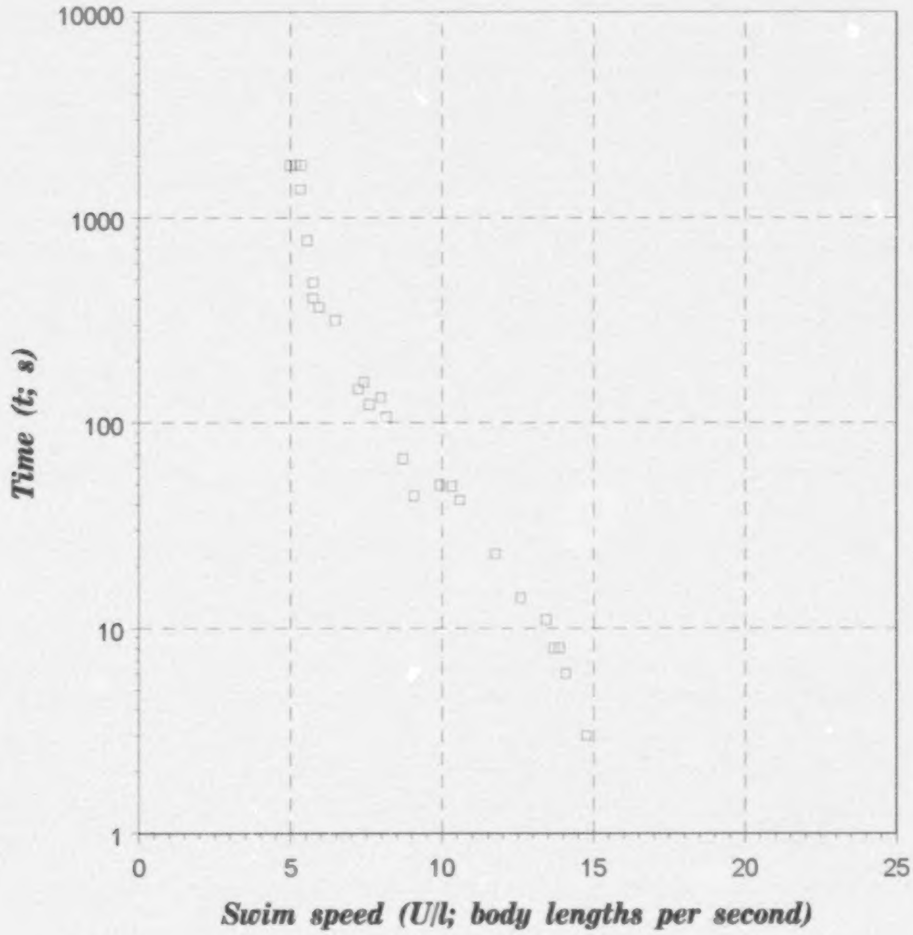


Figure A-010. Preprocessed data for Anguilla australis *(Australian Shortfin Eel): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Langdon and Collins (2000).*

Table A-010. Swim speed data summary. Fish count 26, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.054	0	0.054	0.054	0	1
T (C)	19.8	0	19.8	19.8	0	1
U (m/s)*	0.482	0.177	0.27	0.8	0.53	25
t_e (s)	389	600	3	1800	1797	23
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

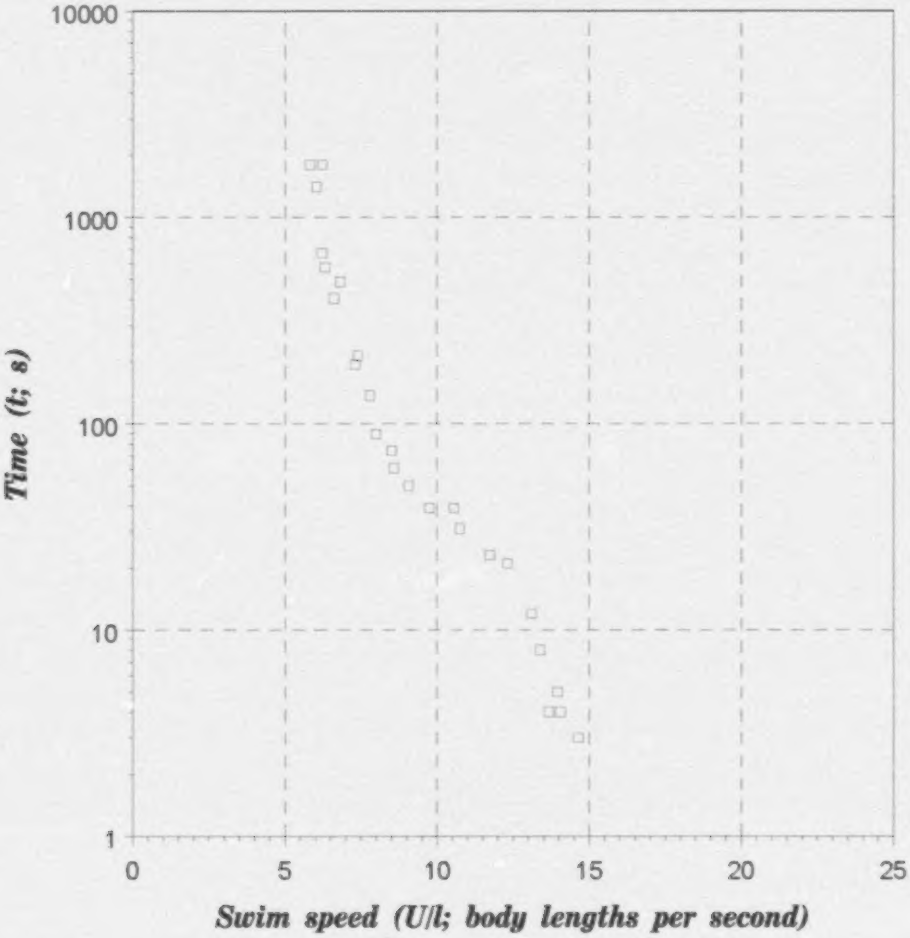


Figure A-011. Preprocessed data for Anguilla reinhardtii *(Longfinned Eel): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Langdon and Collins (2000).*

Table A-011. Swim speed data summary. Fish count 25, record count 25.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0	0.051	0.051	0	1
T (C)	22.7	0	22.7	22.7	0	1
U (m/s)*	0.489	0.154	0.298	0.75	0.452	25
t_e (s)	326	544	3	1800	1979	22
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

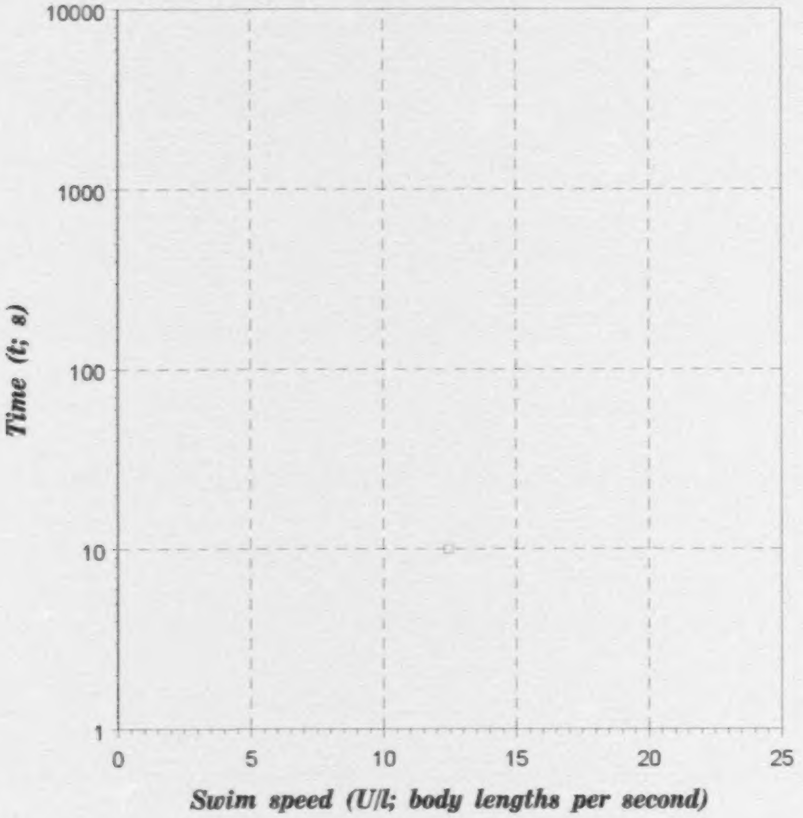


Figure A-012. Preprocessed data for Astyanax mexicanus *(Mexican Tetra): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-012. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.041	0	0.041	0.041	0	1
T (C)	24.9	0	24.9	24.9	0	1
U (m/s)*	0.509	0	0.509	0.509	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

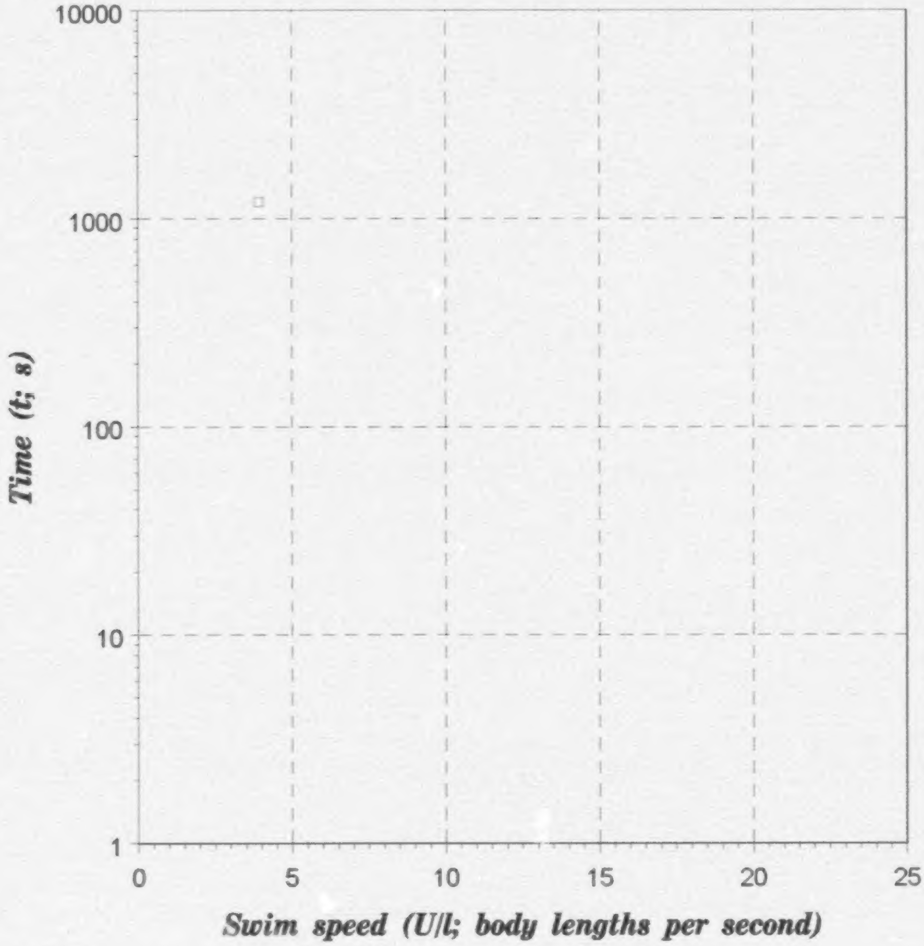


Figure A-013. Preprocessed data for Barbatula barbatula *(Stone Loach): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Tudorache et al. (2008).*

Table A-013. Swim speed data summary. Fish count 8, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.072	0	0.072	0.072	0	1
T (C)	15	0	15	15	0	1
U (m/s)*	0.283	0	0.283	0.283	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	1200	0	1200	1200	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

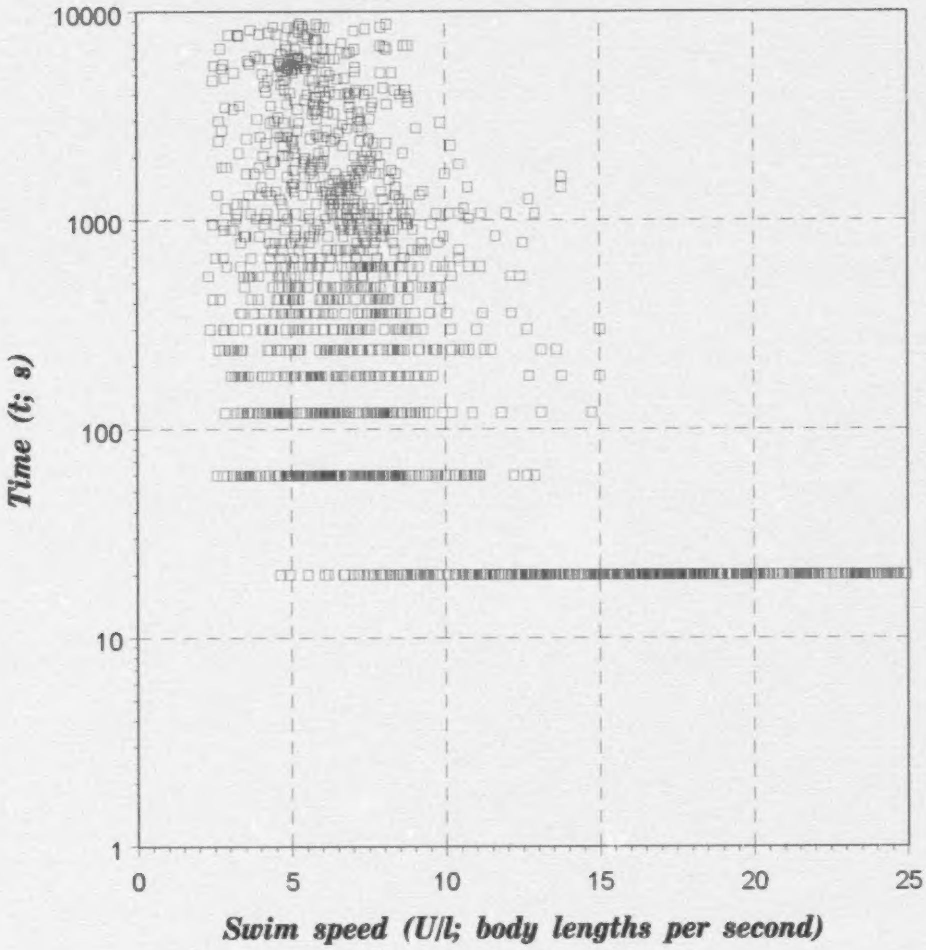


Figure A-014. Preprocessed data Barbus barbus *(Barbel): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Clough et al. (2003).*

Table A-014. Swim speed data summary. Fish count 1678, record count 1678.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.13	0.047	0.053	0.247	0.194	191
T (C)	12.8	4.6	5.2	23.5	18.3	181
U (m/s)*	1.199	0.702	0.479	3.82	3.341	355
t_e (s)	1326	1932	60	8820	8760	118
$t_{\Delta t}$ (s)**	20	0	20	20	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

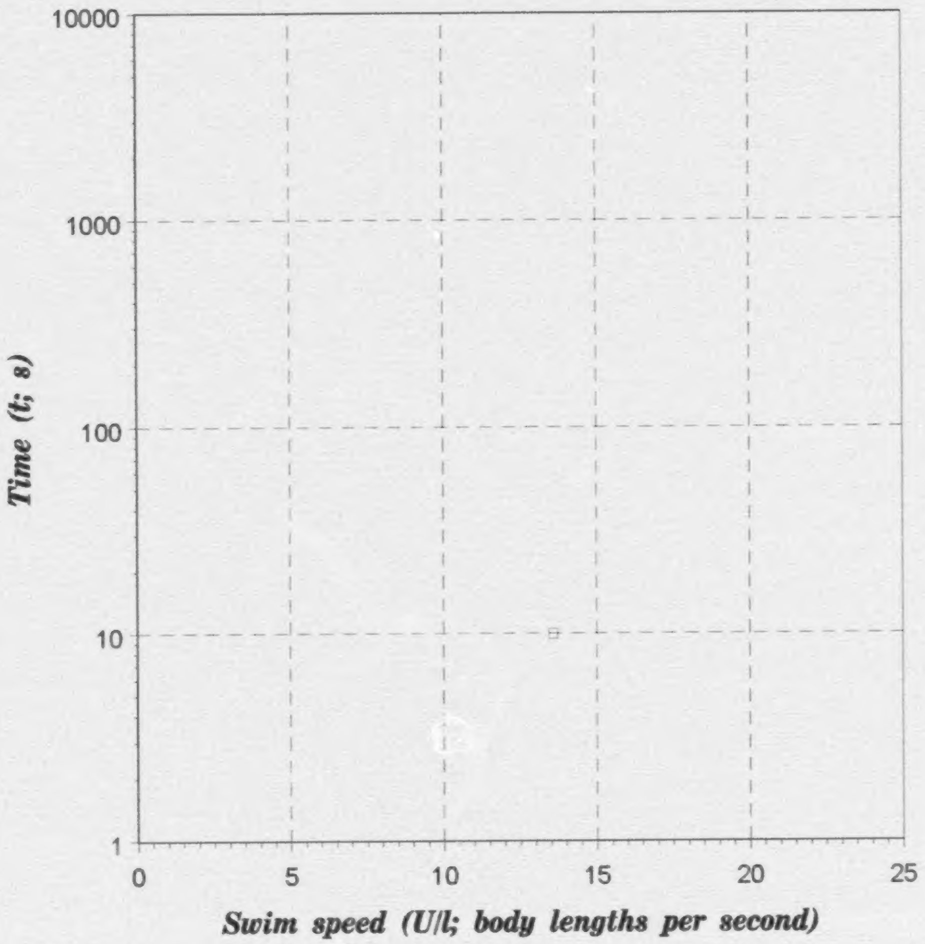


Figure A-015. Preprocessed data Campostoma anomalum *(Central Stoneroller): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-015. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.046	0	0.046	0.046	0	1
T (C)	28.2	0	28.2	28.2	0	1
U (m/s)*	0.629	0	0.629	0.629	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

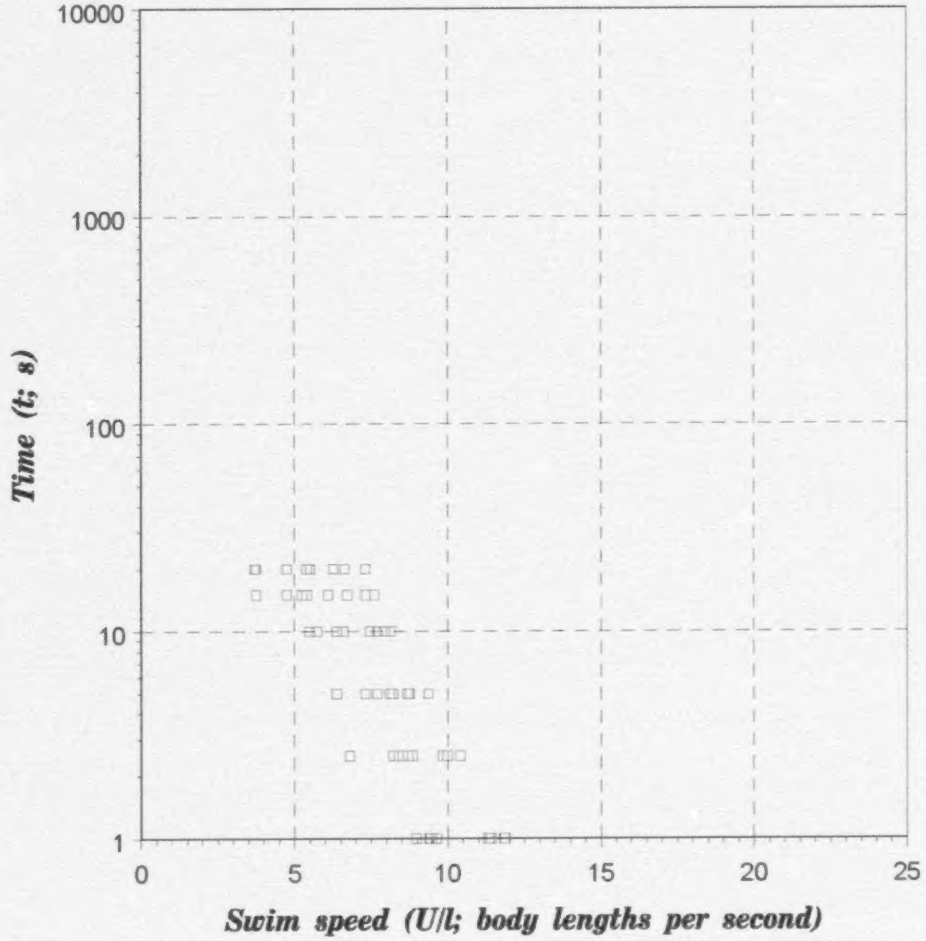


Figure A-016. Preprocessed data Carassius auratus *(Goldfish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Bainbridge (1960).*

Table A-016. Swim speed data summary. Fish count 48, record count 48.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.129	0.043	0.067	0.213	0.146	8
T (C)	15	0	15	15	0	1
U (m/s)*	0.947	0.352	0.42	2	1.58	35
t_e (s)	9	7	1	20	19	6
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

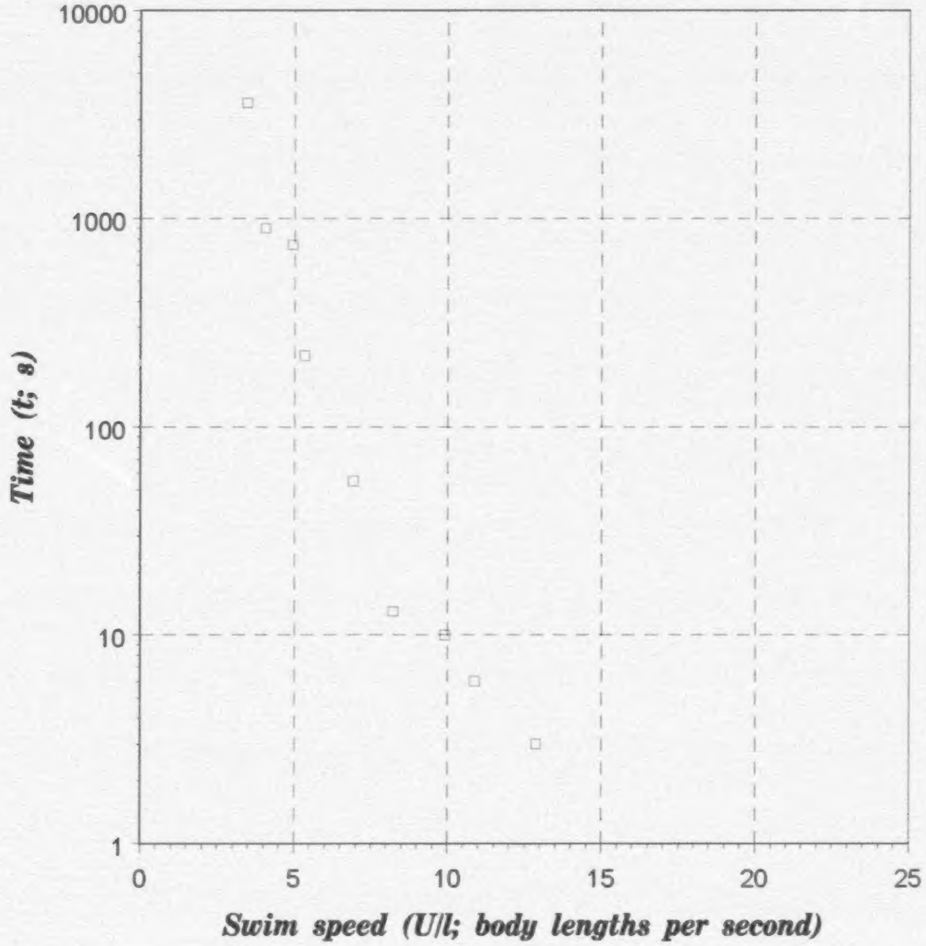


Figure A-017. Preprocessed data Carassius carassius *(Crucian Carp): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Tsukamoto et al. (1975).*

Table A-017. Swim speed data summary. Fish count 45, record count 9.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.101	0	0.101	0.101	0	1
T (C)	13	0	13	13	0	1
U (m/s)*	0.748	0.316	0.35	1.3	0.95	9
t_e (s)	617	1116	3	3600	3597	9
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

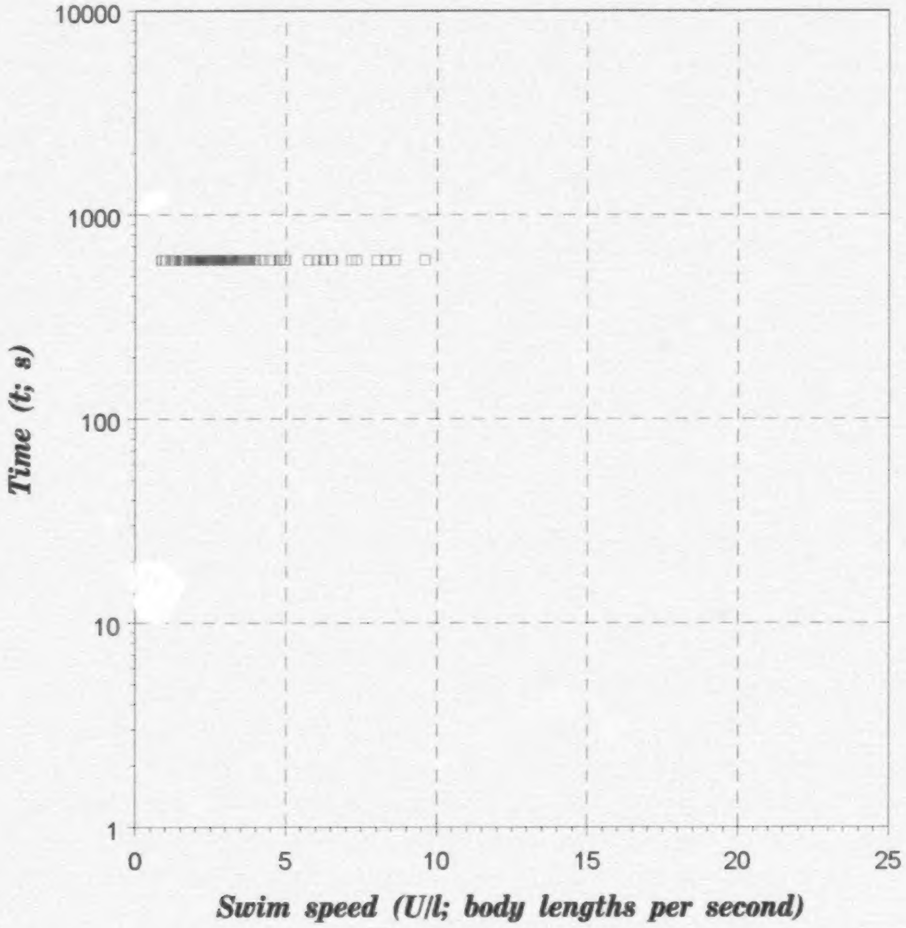


Figure A-018. Preprocessed data Catostomus catostomus *(Longnose Sucker): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973).*

Table A-018. Swim speed data summary. Fish count 150, record count 150.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.22	0.112	0.04	0.53	0.49	37
T (C)	13.5	0	13.5	13.50	0	1
U (m/s)*	0.568	0.212	0.15	1.08	0.93	57
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

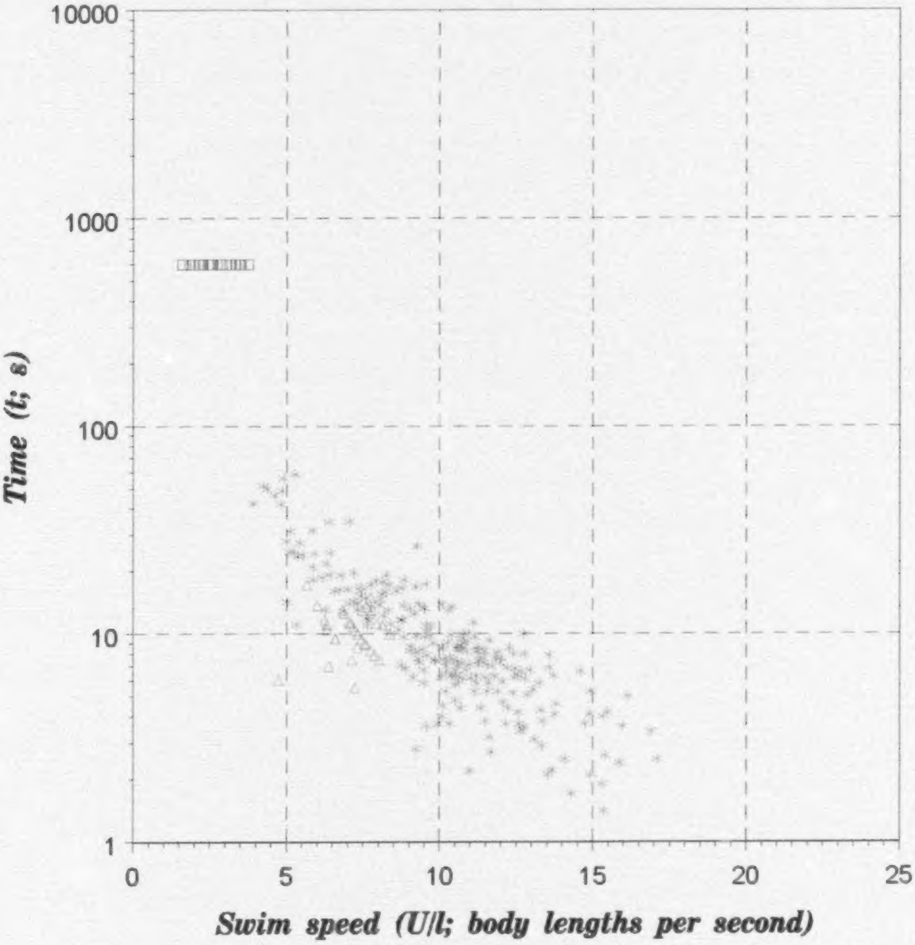


Figure A-019. Preprocessed data Catostomus commersoni *(White Sucker): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973); red triangles are data from McAuley (1996); green stars are data from Castro-Santos (2005).*

Table A-019. Swim speed data summary. Fish count 287, record count 287.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.383	0.051	0.16	0.5	0.34	16
T (C)	14.2	1.5	10.5	16	5.5	3
U (m/s)*	3.611	1.329	0.33	6.74	6.41	210
t_e (s)	11	9	1	59	57	150
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

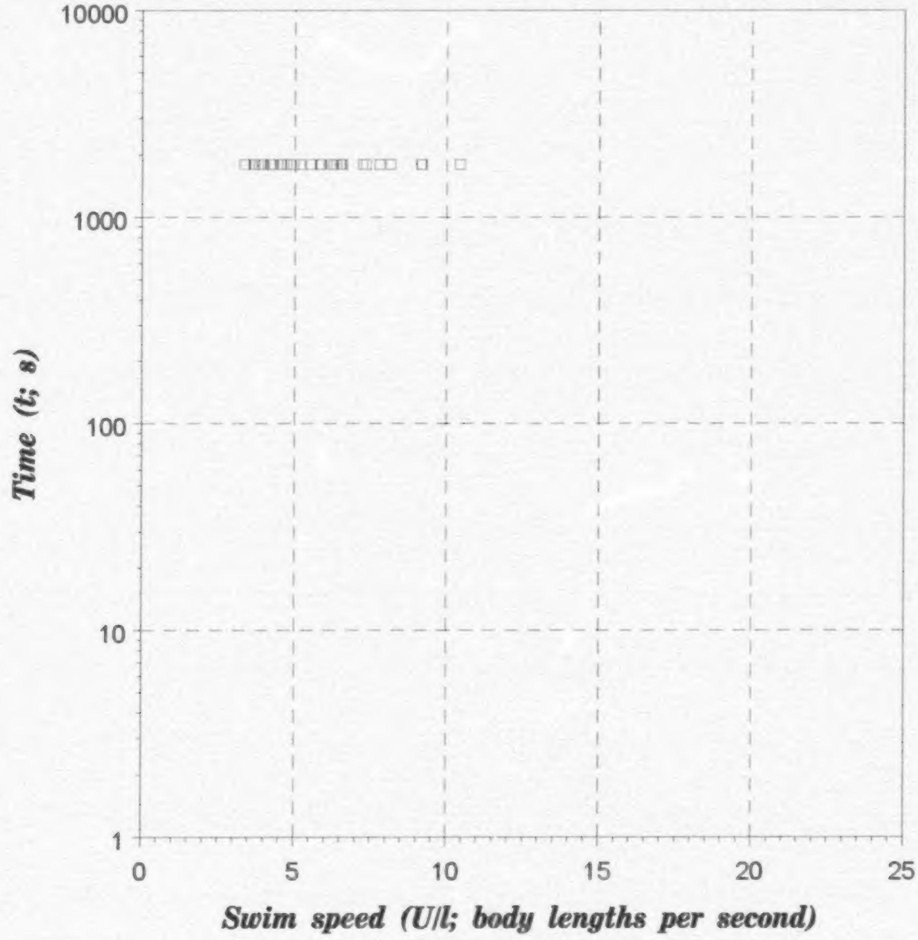


Figure A-020. Preprocessed data Catostomus laipinnis *(Flannelmouth Sucker): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Ward et al. (2002).*

Table A-020. Swim speed data summary. Fish count 588, record count 30.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.064	0.026	0.024	0.114	0.09	28
T (C)	14.6	4.1	10	20	10	3
U (m/s)*	0.351	0.118	0.157	0.663	0.506	29
t_e (s)	1800	0	1800	1800	0	1
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity

** t=time step (Δt)

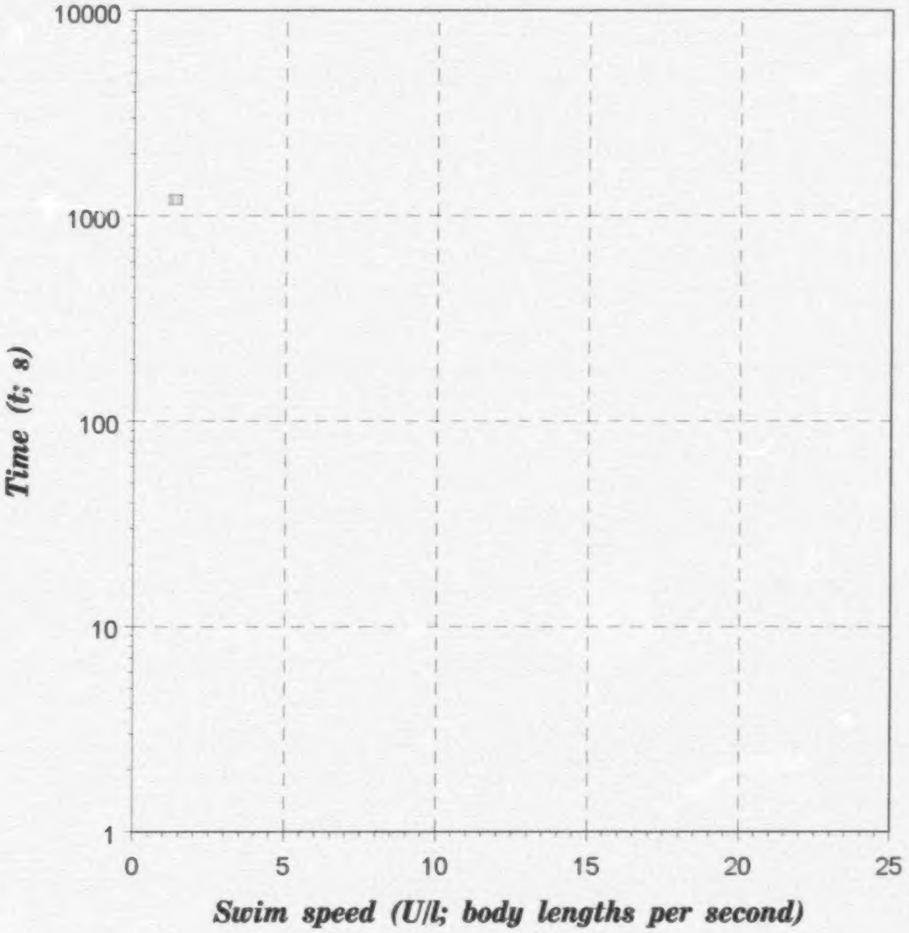


Figure A-021. Preprocessed data Catostomus macrochellus *(Largescale Sucker): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Kolok et al. (1993).*

Table A-021. Swim speed data summary. Fish count 24, record count 4.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.397	0	0.397	0.397	0	1
T (C)	13	3.1	10	16	6	2
U (m/s)*	0.535	0.021	0.503	0.562	0.059	3
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	1200	0	1200	1200	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

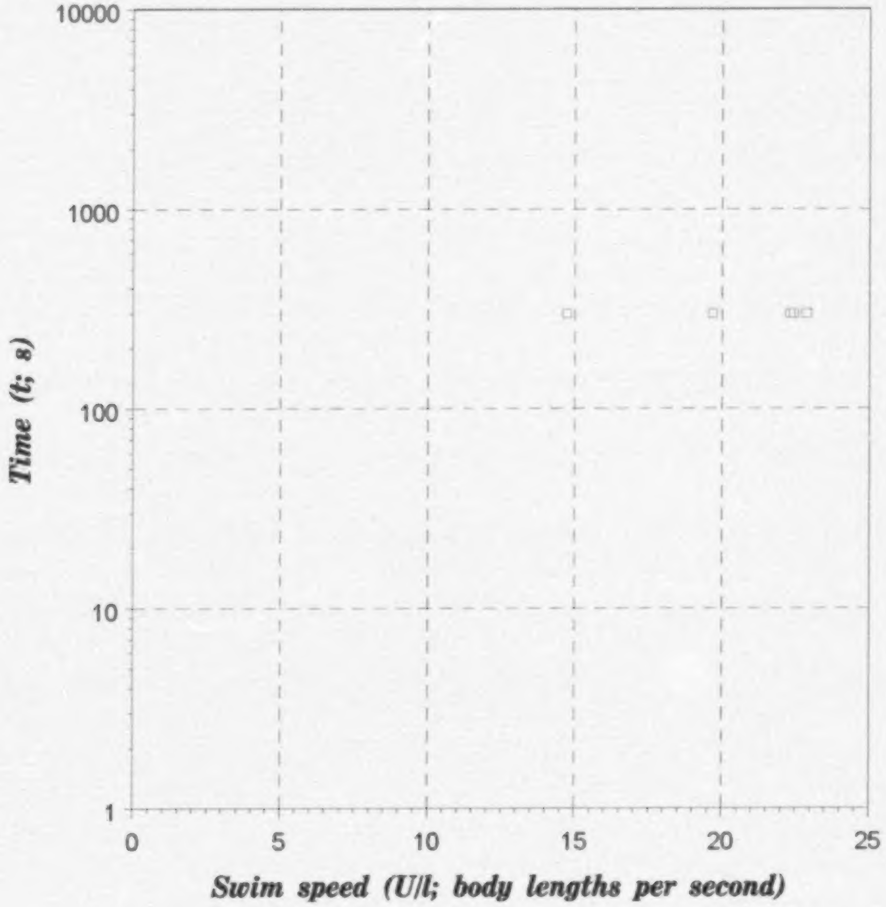


Figure A-022. Preprocessed data Catostomus platyrhynchus *(Mountain Sucker): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Aedo et al. (2009).*

Table A-022. Swim speed data summary for Fish count 14, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.025	0.002	0.022	0.029	0.007	7
T (C)	17	0	17	17	0	1
U (m/s)*	0.641	0.172	0.324	0.962	0.638	13
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

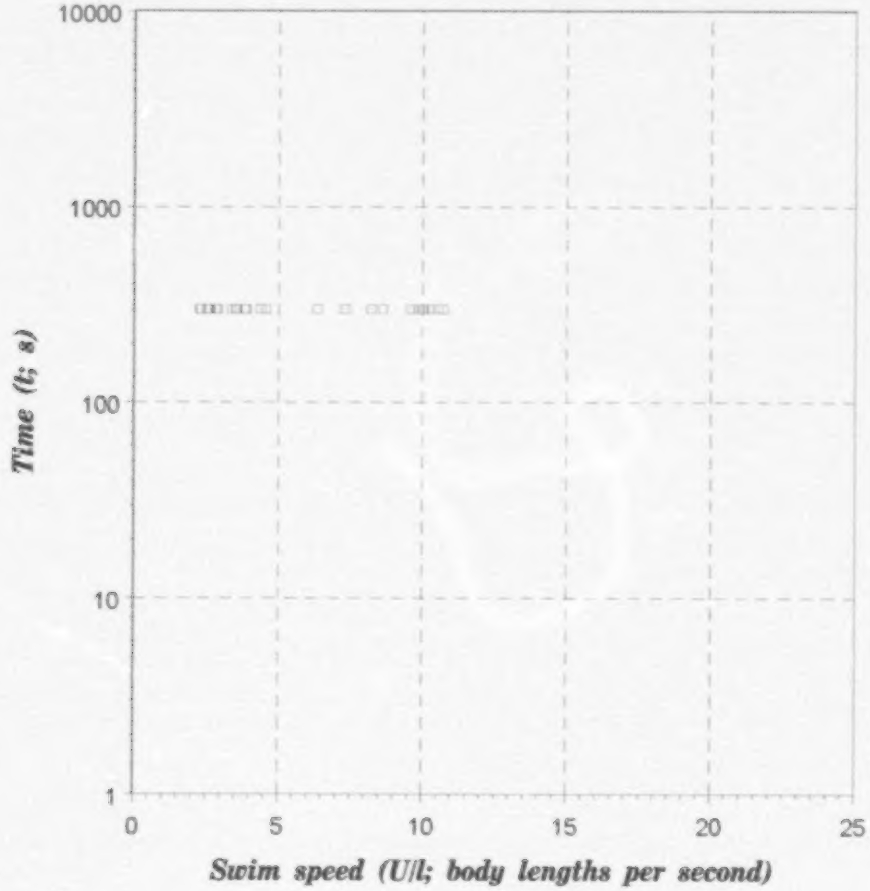


Figure A-023. Preprocessed data Chasmistes liorus *(June Sucker): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Aedo et al. (2009).*

Table A-023. Swim speed data summary. Fish count 26, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.1	0.061	0.028	0.205	0.177	24
T (C)	17	0	17	17	0	1
U (m/s)*	0.42	0.085	0.222	0.549	0.327	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

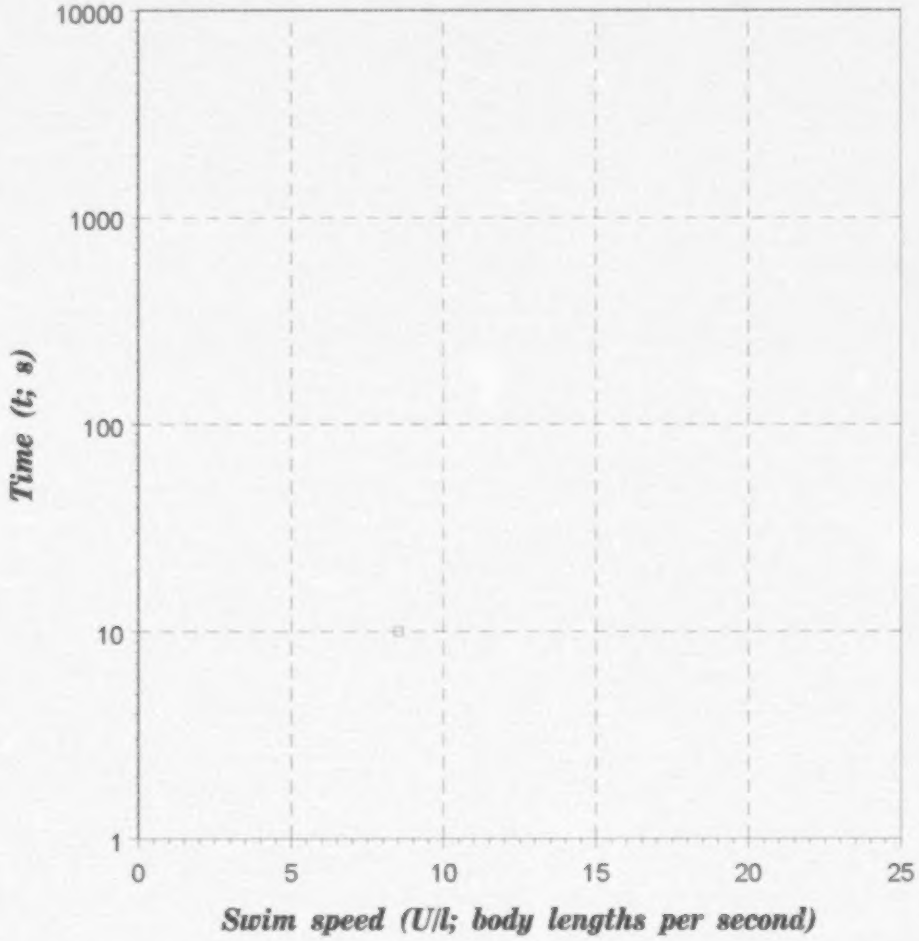


Figure A-024. Preprocessed data Cichlasoma cyanoguttatum *(Rio Grande Cichlid): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-024. Swim speed data summary for. Fish count 8, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.039	0	0.039	0.039	0	1
T (C)	25.6	0	25.6	25.6	0	1
U (m/s)*	0.33	0	0.33	0.33	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

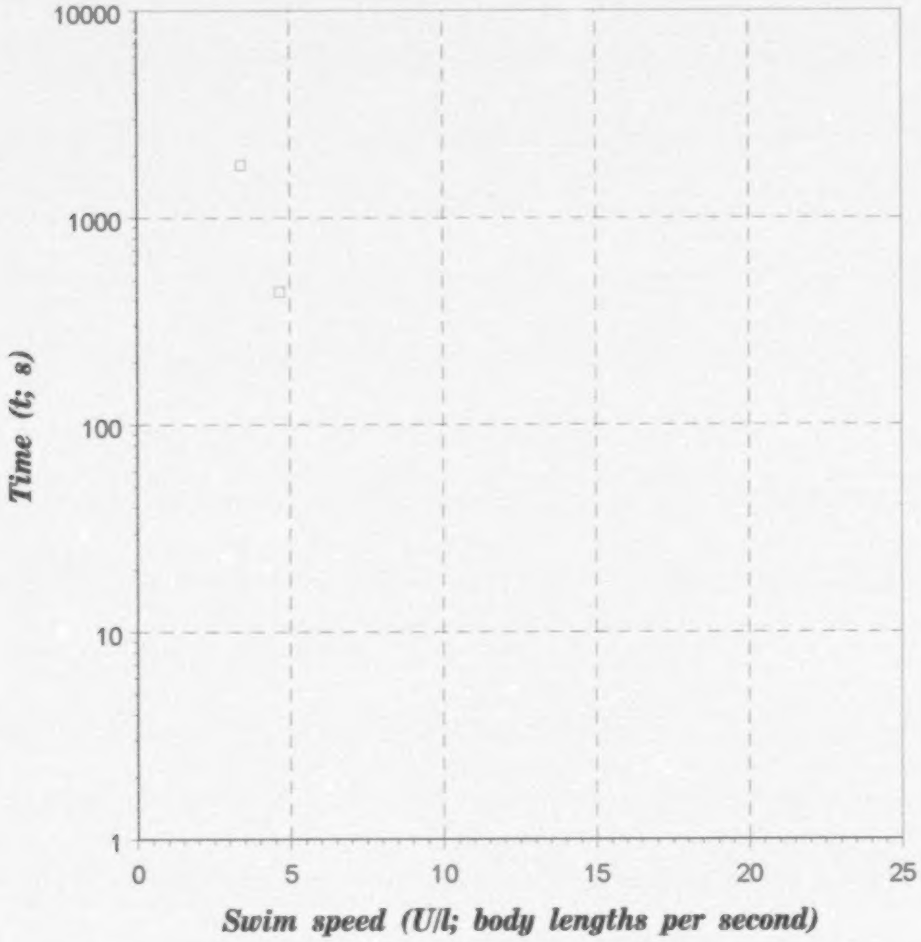


Figure A-025. Preprocessed data Coregonus artedii *(Cisco): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Bernatchez and Dodson (1985).*

Table A-025. Swim speed data summary for. Fish count 28, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.135	0	0.135	0.135	0	1
T (C)	12	0	12	12	0	1
U (m/s)*	0.581	0.079	0.458	0.63	0.172	2
t_e (s)	438	0	438	438	0	1
$t_{\Delta t}$ (s)**	1800	0	1800	1800	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

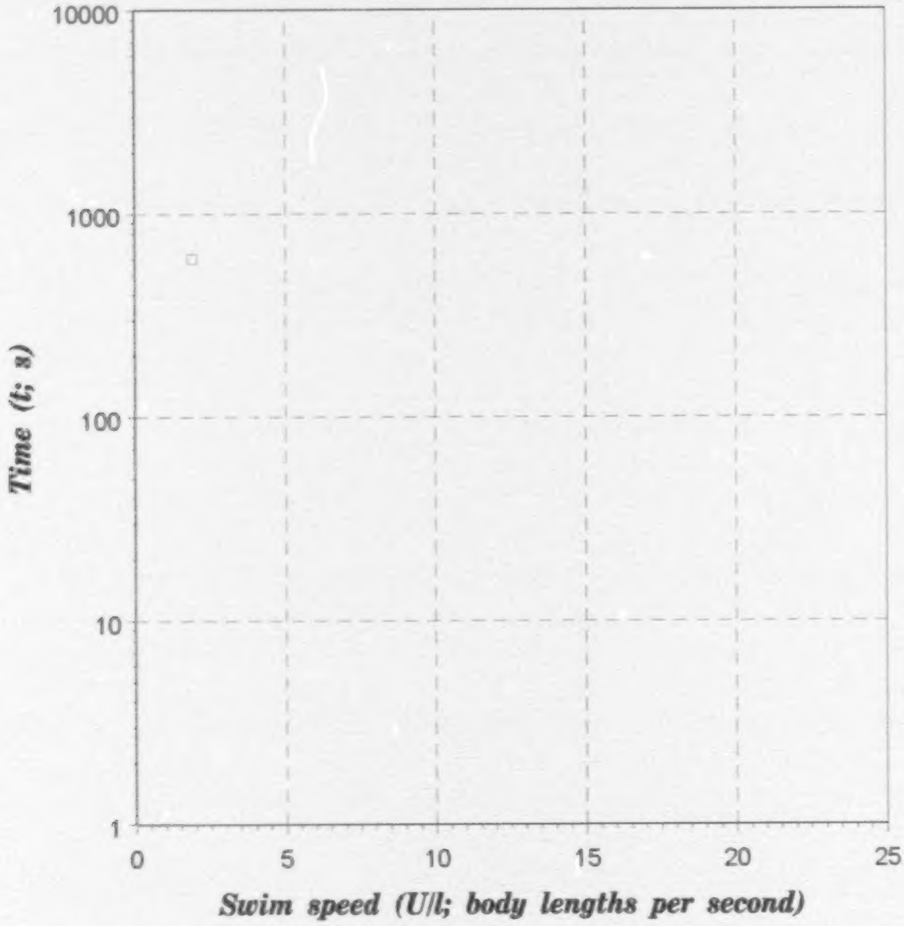


Figure A-026. Preprocessed data for Coregonus autumnalis *(Arctic Cisco): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Jones et al. (1973).*

Table A-026. Swim speed data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.42	0	0.42	0.42	0	1
T (C)	10	0	10	10	0	1
U (m/s)*	0.8	0	0.8	0.8	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

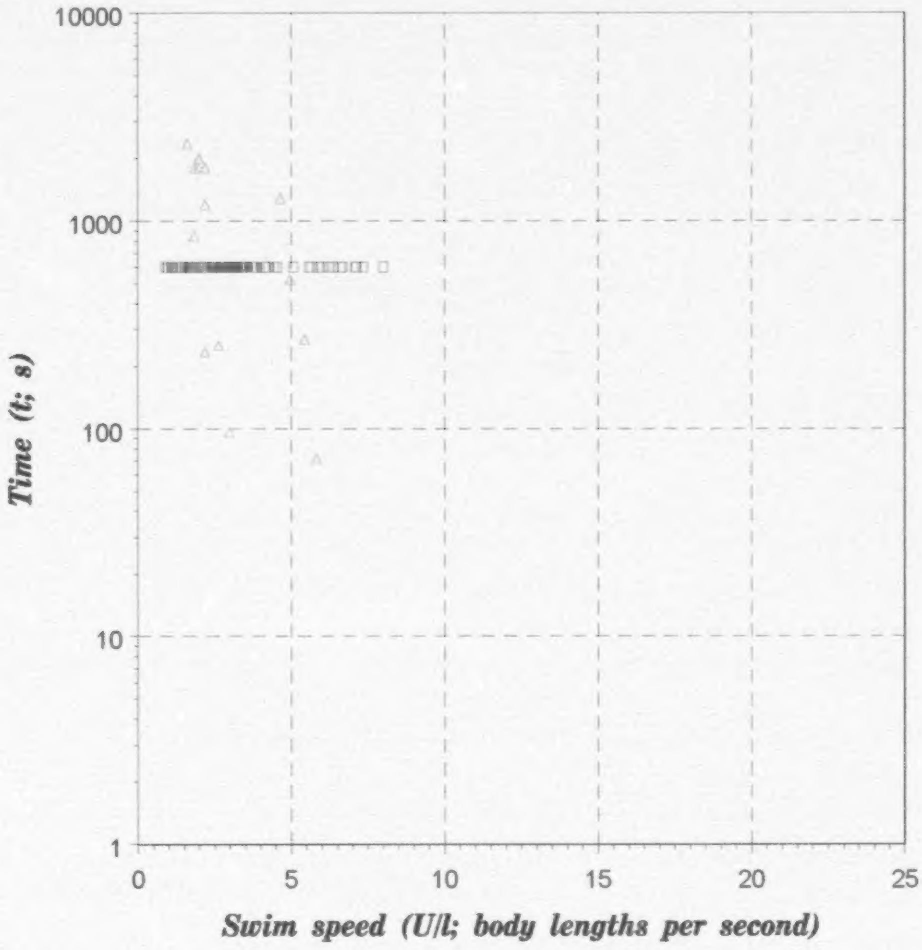


Figure A-027. Preprocessed data for Coregonus clupeaformis *(Lake Whitefish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973); red triangles are data from Bernatchez and Dodson (1985).*

Table A-027. Swim speed data summary. Fish count 322, record count 177.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.224	0.097	0.07	0.52	0.45	32
T (C)	12.1	2.7	5	17	12	4
U (m/s)*	0.618	0.164	0.15	1.02	0.87	60
t_e (s)	803	683	72	2358	2286	11
$t_{\Delta t}$ (s)**	771	420	600	1800	1200	2

* U=critical velocity (U_{crit})

** t=time step (Δt)

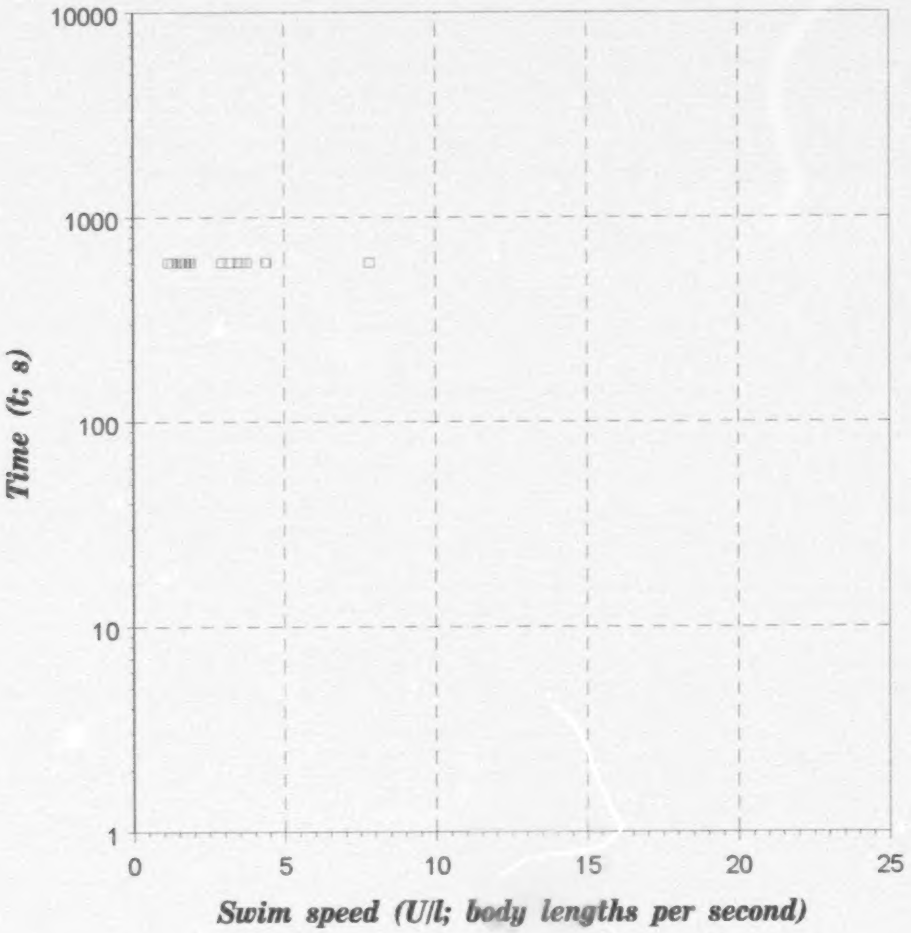


Figure A-028. Preprocessed data for Coregonus nasus *(Broad Whitefish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973).*

Table A-028. Swim speed data summary. Fish count 21, record count 21.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.206	0.096	0.05	0.33	0.28	15
T (C)	12.5	0	12.5	12.5	0	1
U (m/s)*	0.437	0.102	0.21	0.66	0.45	16
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

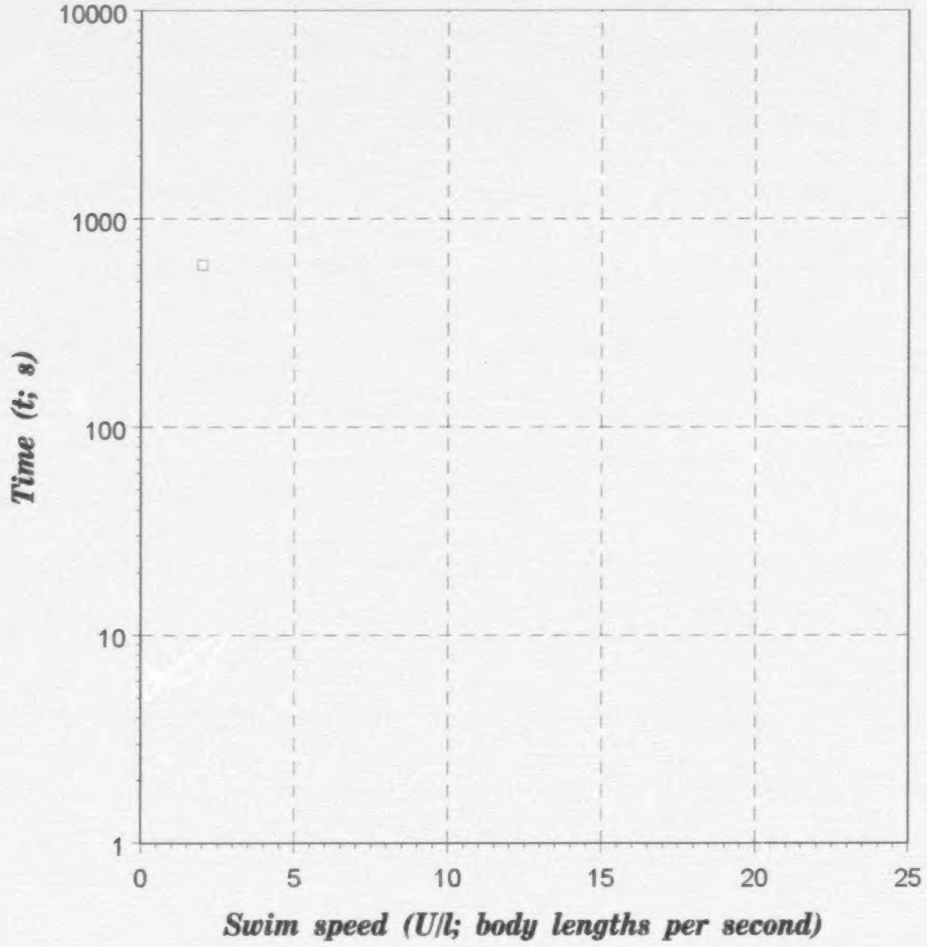


Figure A-029. Preprocessed data for Coregonus sardinella (Least Cisco)*: swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Jones et al. (1973).*

Table A-029. Swim speed data summary. Fish count 2, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0	0.3	0.3	0	1
T (C)	16	0	16	16	0	1
U (m/s)*	0.6	0	0.6	0.6	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

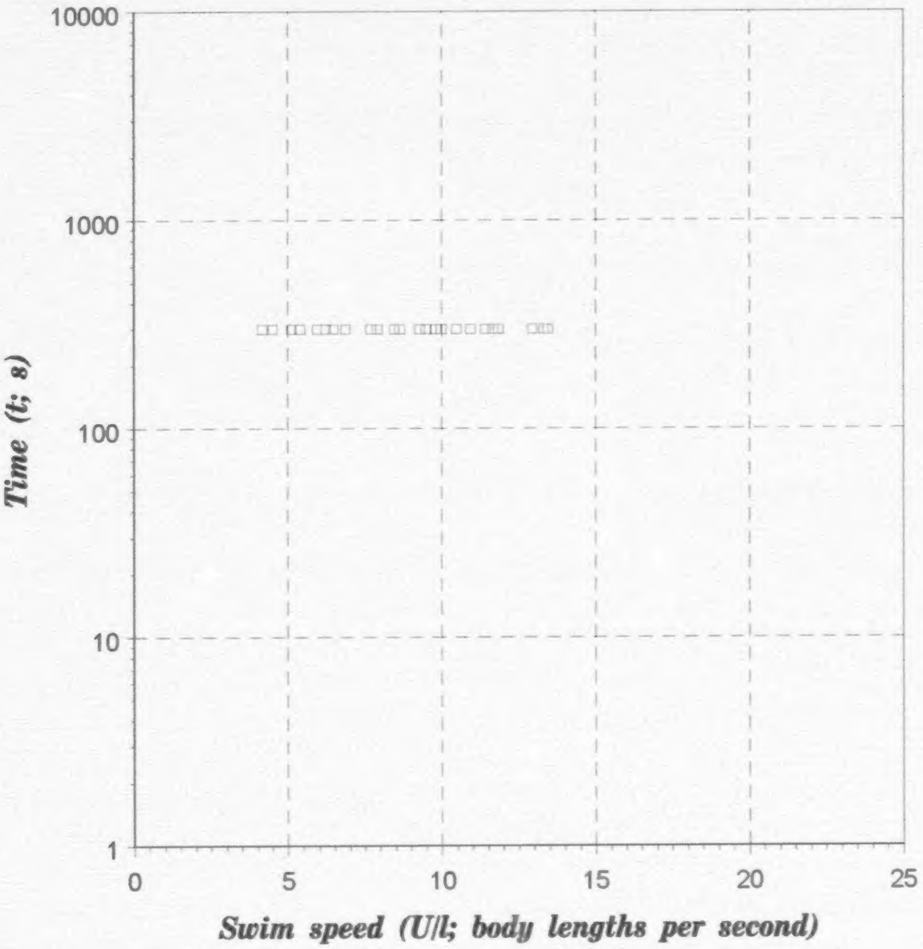


Figure A-030. Preprocessed data for Cottus bairdi *(Mottled Sculpin): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Aedo et al. (2009).*

Table A-030. Swim speed data summary. Fish count 24, record count 24.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.061	0.013	0.029	0.086	0.057	17
T (C)	17	0	17	17	0	1
U (m/s)*	0.523	0.164	0.252	0.841	0.589	23
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

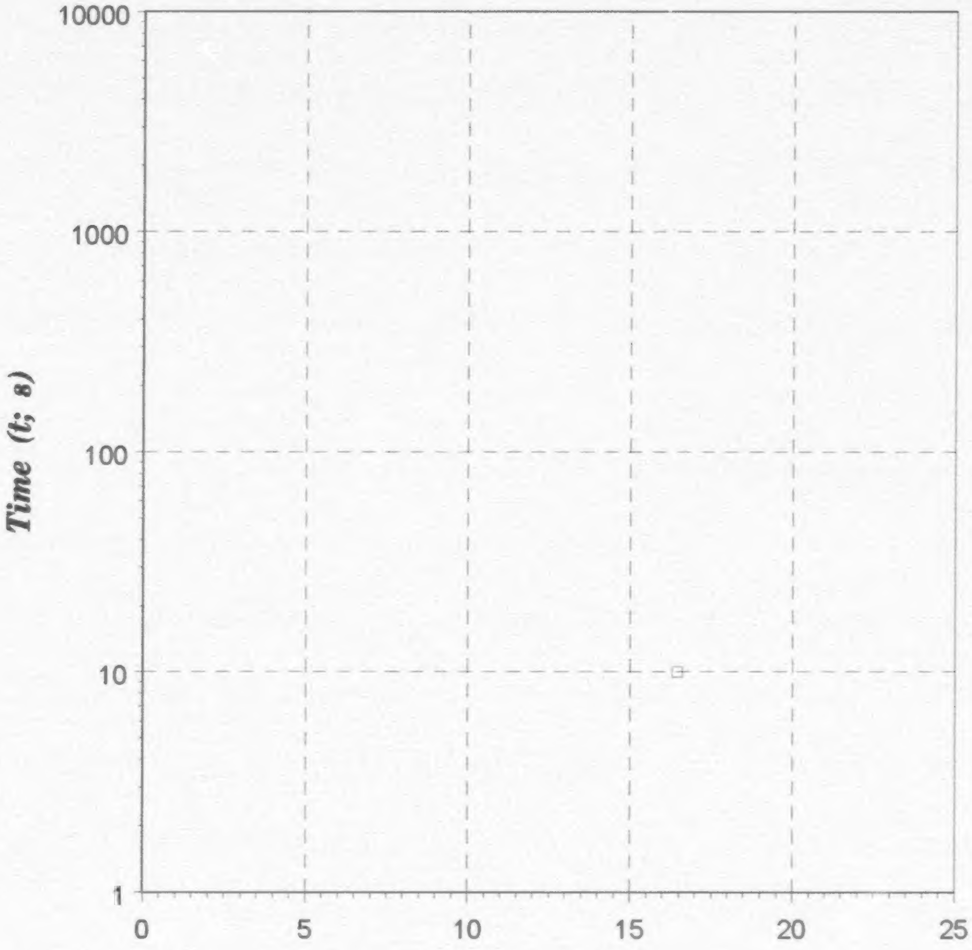


Figure A-031. Preprocessed data for Cyprinella lutrensis *(Red Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-031. Swim speed data summary. Fish count 16, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	27.7	0	27.7	27.7	0	1
U (m/s)*	0.712	0	0.712	0.712	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

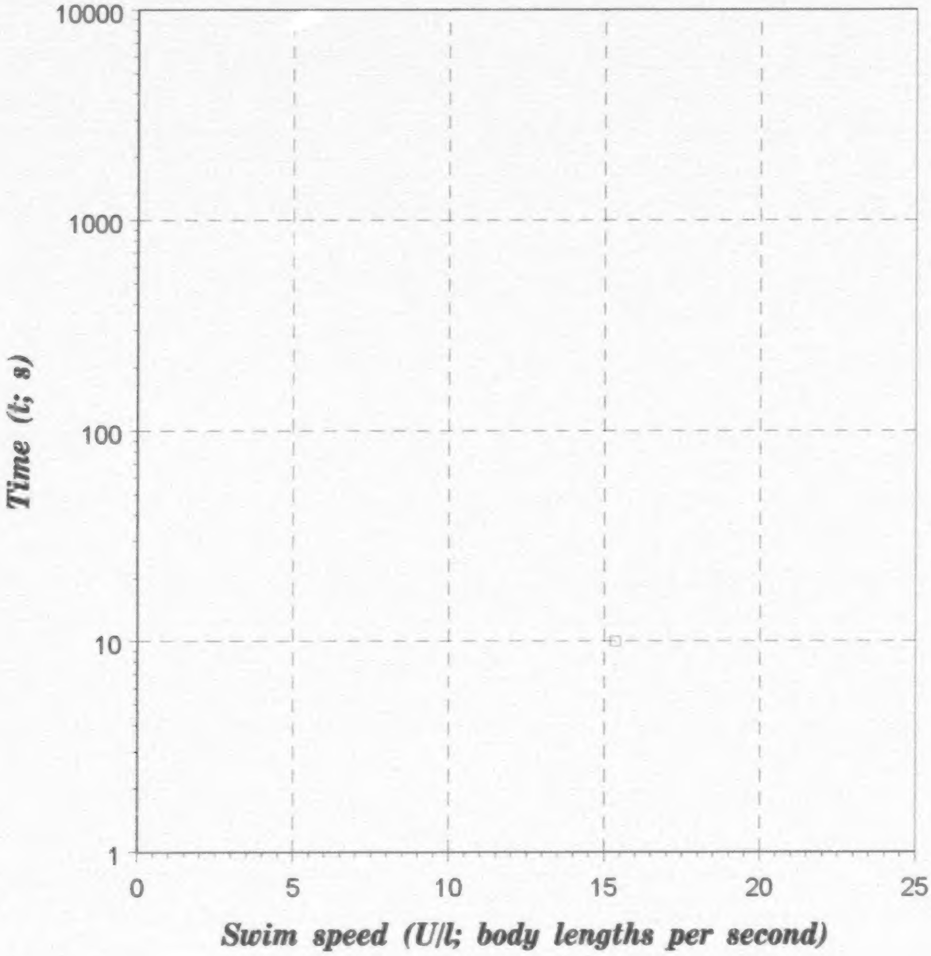


Figure A-032. Preprocessed data for Cyprinella proserpina *(Proserpine Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-032. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0	0.04	0.04	0	1
T (C)	23.5	0	23.5	23.5	0	1
U (m/s)*	0.608	0	0.608	0.608	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

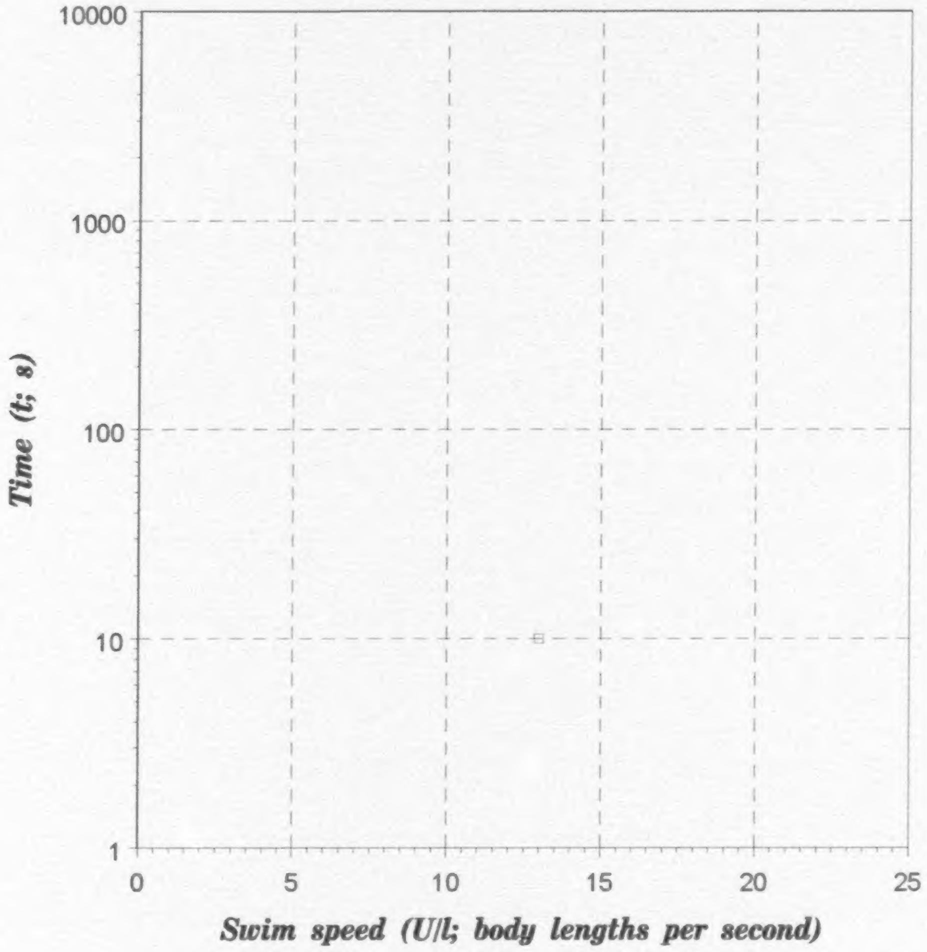


Figure A-033. Preprocessed data for Cyprinella venusta *(Blacktail Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-033. Swim speed data summary. Fish count 19, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.047	0	0.047	0.47	0	1
T (C)	23.1	0	23.1	23.1	0	1
U (m/s)*	0.611	0	0.611	0.611	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

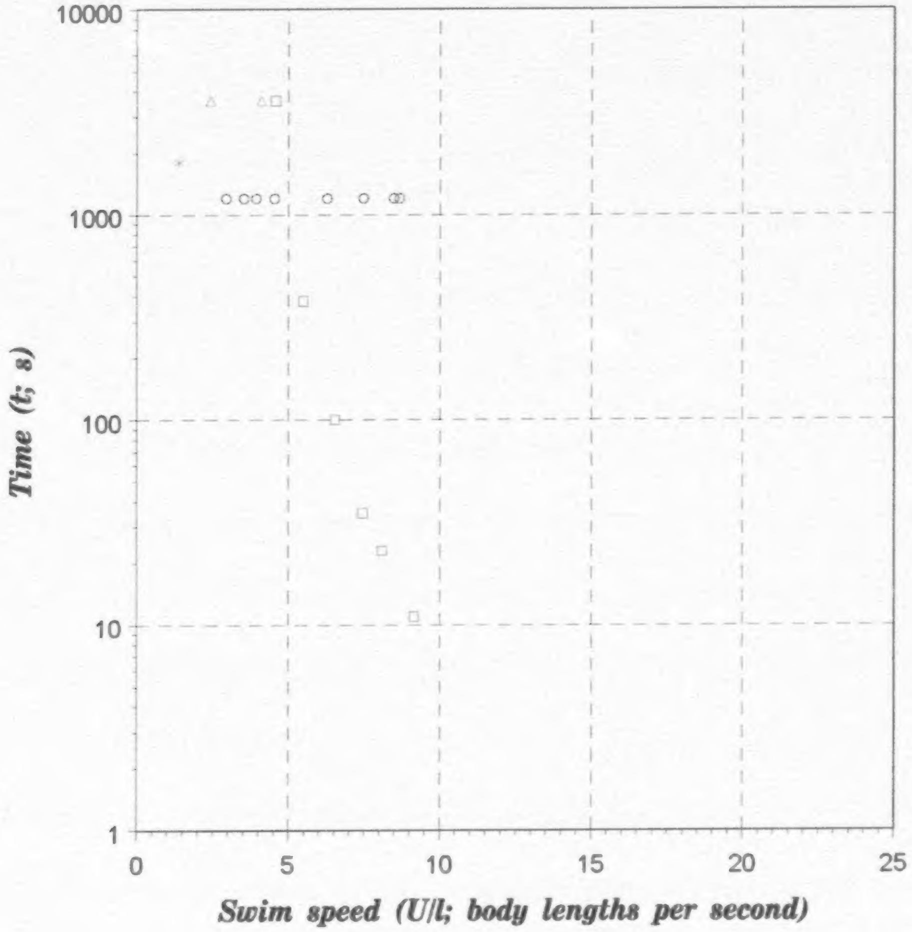


Figure A-034. Preprocessed data for Cyprinus carpio *(Carp): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Tsukamoto et al. (1975); red triangles are data from Heap and Goldspink(1986); green stars are data from West et al. (1994); black circles are data from Tudorache et al. (2007); turquoise diamonds are data from Tudorache et al. (2008).*

Table A-034. Swim speed data summary. Fish count 147, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.152	0.088	0.049	0.44	0.391	11
T (C)	17.9	4.2	10	22	12	5
U (m/s)*	0.704	0.288	0.233	1.4	1.167	19
t_e (s)	692	1329	11	3600	3589	6
$t_{\Delta t}$ (s)**	1703	952	1200	3600	2400	3

* U=critical velocity (U_{crit})
** t=time step (Δt)

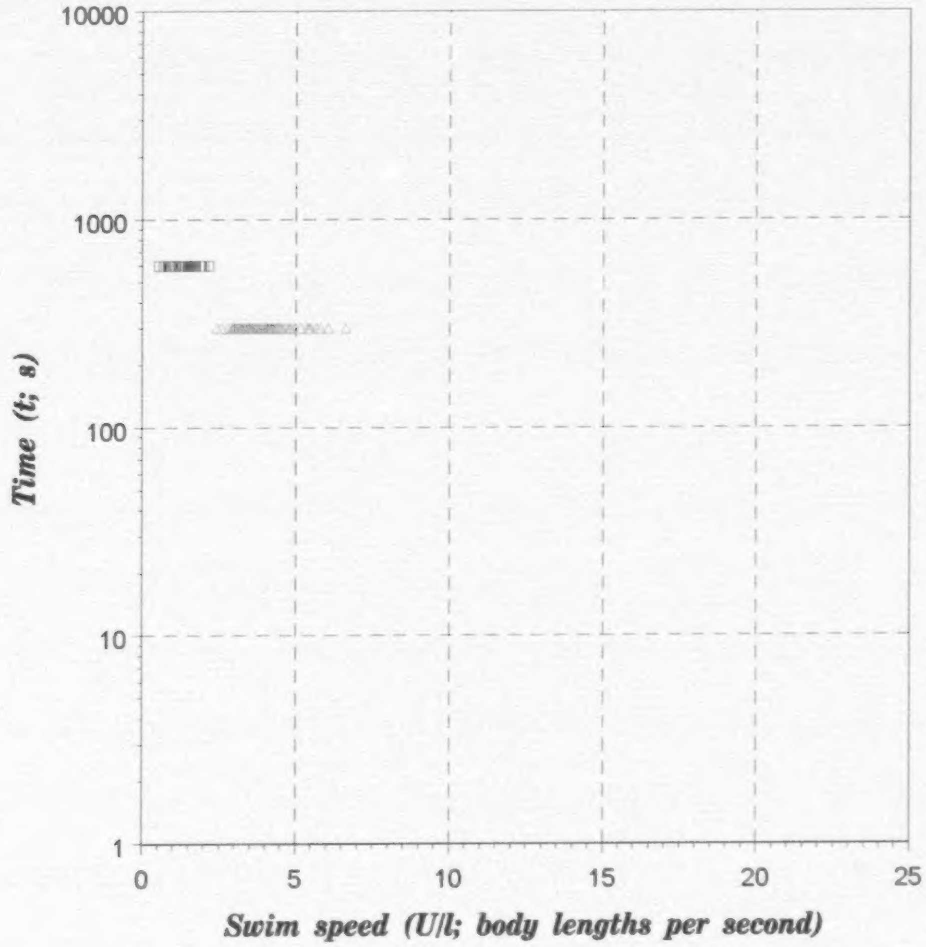


Figure A-035. Preprocessed data for Esox lucius *(Northern Pike): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973); red triangles are data from Peake (2004b).*

Table A-035. Swim speed data summary. Fish count 128, record count 128.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.108	0.095	0.023	0.48	0.457	78
T (C)	16.5	3.4	12	19	7	2
U (m/s)*	0.221	0.076	0.099	0.5	0.401	63
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	405	144	300	600	300	2

* U=critical velocity (U_{crit})
** t=time step (Δt)

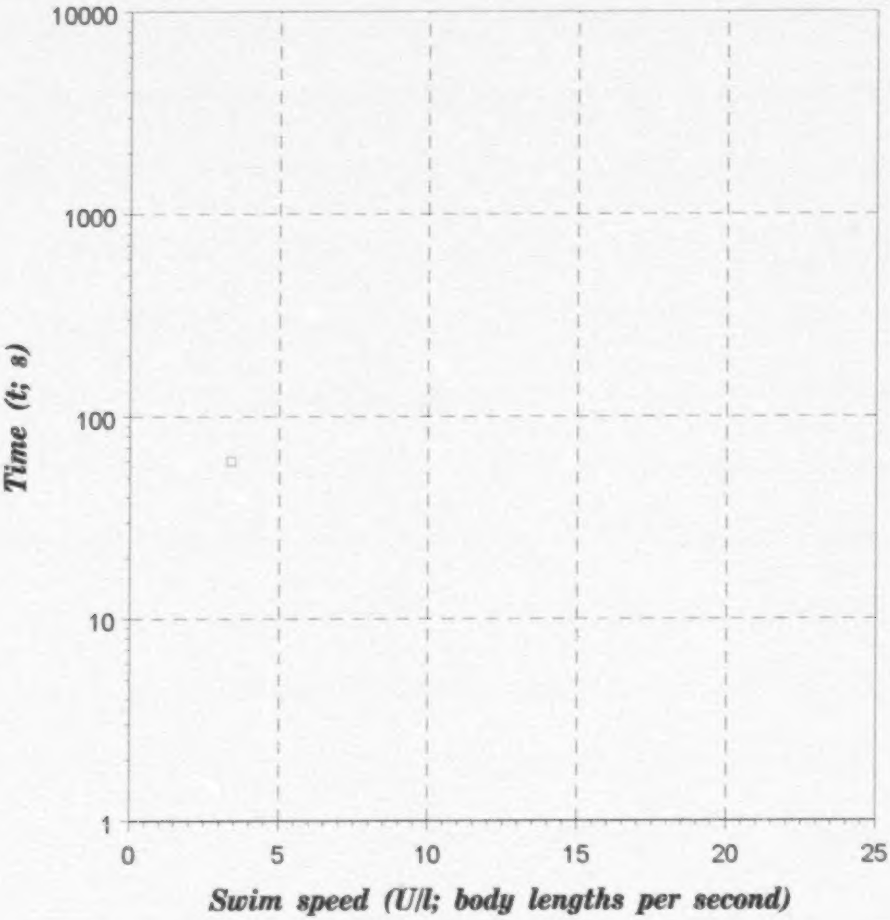


Figure A-036. Preprocessed data for Esox sp. *(Tiger Muskellunge): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Webb et al. (1992).*

Table A-036. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.189	0	0.189	0.189	0	1
T (C)	25	0	25	25	0	1
U (m/s)*	0.642	0	0.642	0.642	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	60	0	60	60	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

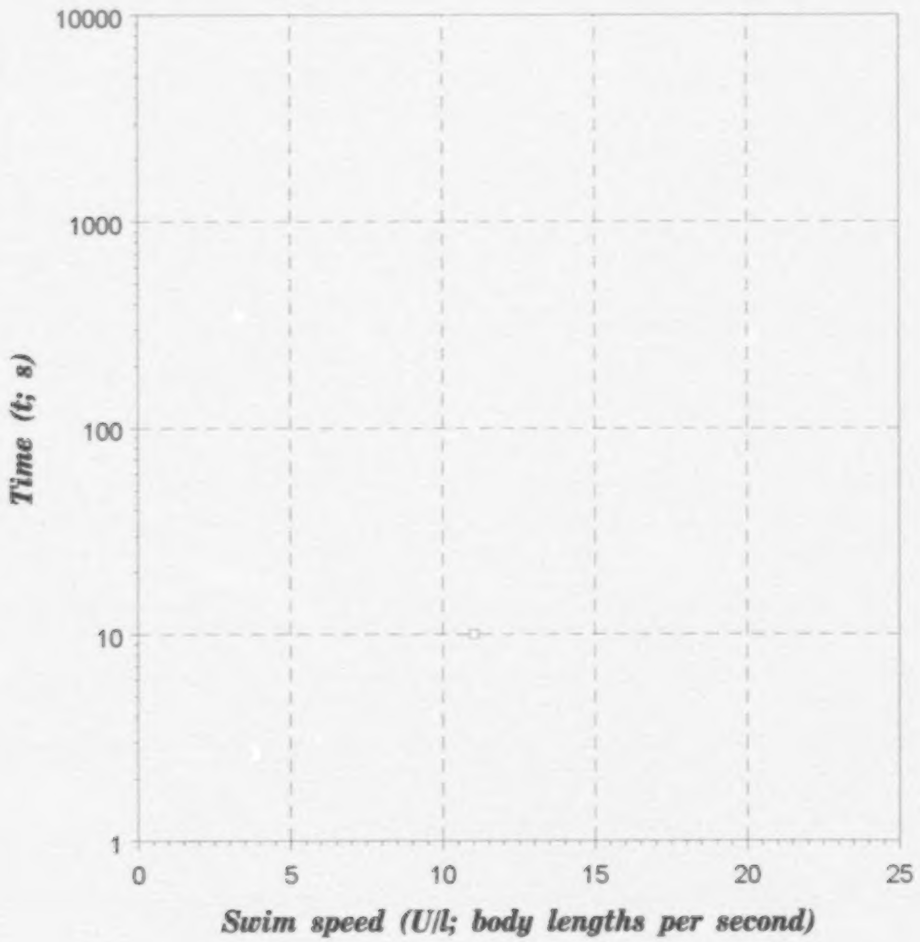


Figure A-037. Preprocessed data for Etheostoma grahami *(Rio Grande Darter): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner. (2009).*

Table A-037. Swim speed data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	24.1	0	24.1	24.1	0	1
U (m/s)*	0.4	0	0.4	0.4	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

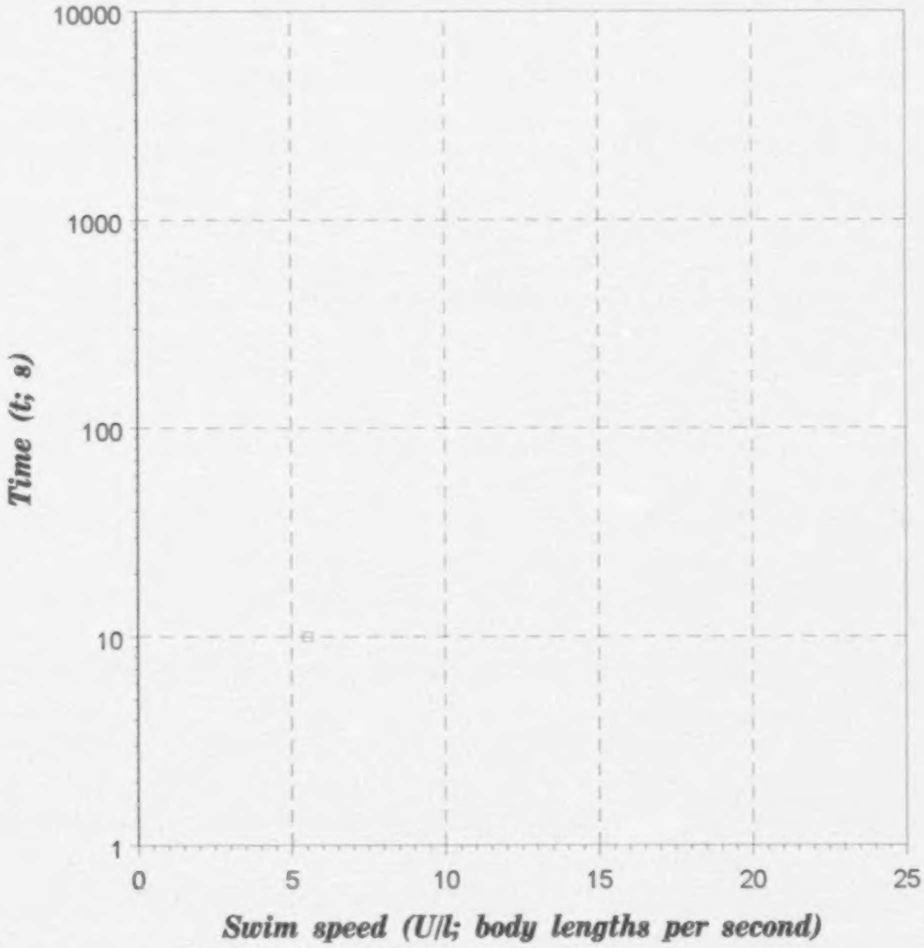


Figure A-038. Preprocessed data for Fundulus notatus *(Blackstripe Topminnow): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-038. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.056	0	0.056	0.056	0	1
T (C)	28.3	0	28.3	28.3	0	1
U (m/s)*	0.307	0	0.307	0.307	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

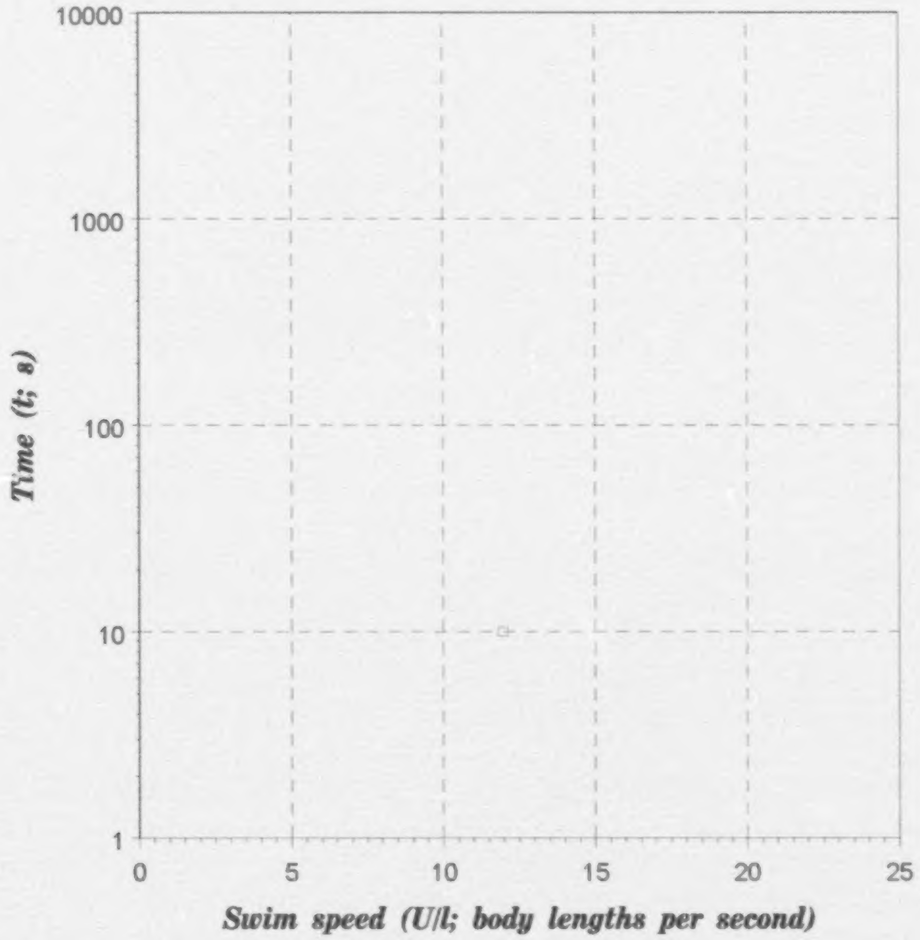


Figure A-039. Preprocessed data for Fundulus zebrinus *(Plains Killifish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-039. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	23.6	0	23.6	23.6	0	1
U (m/s)*	0.434	0	0.434	0.434	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

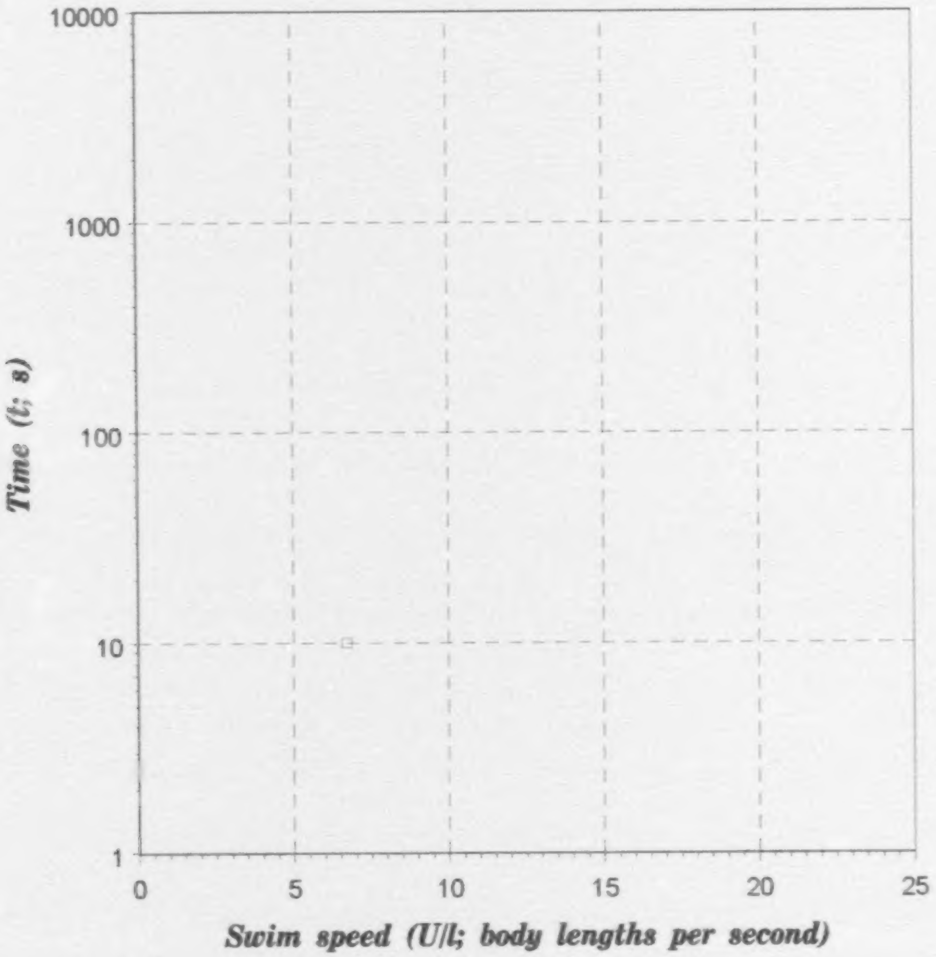


Figure A-040. Preprocessed data for Gambusia geiseri *(Largespring Gambusia): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner 2009.*

Table A-040. Swim speed data summary. Fish count 7, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.023	0	0.023	0.023	0	1
T (C)	22.7	0	22.7	22.7	0	1
U (m/s)*	0.157	0	0.157	0.157	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

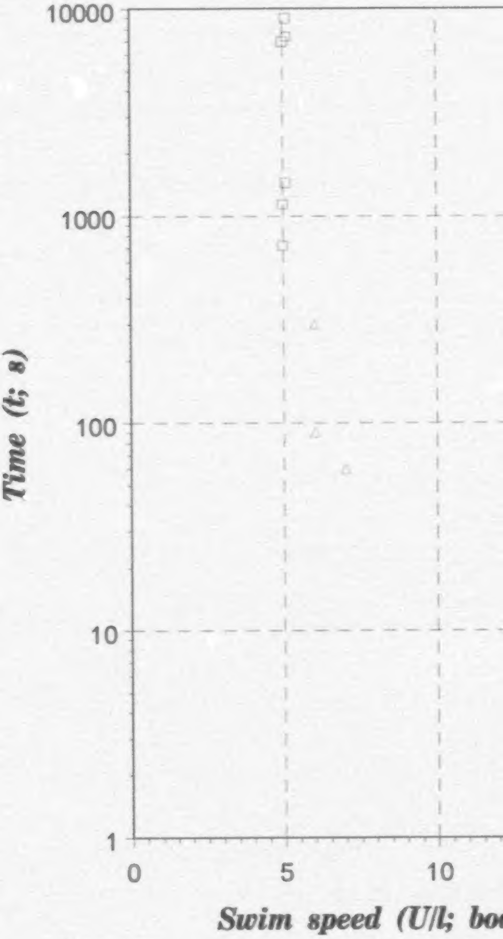


Figure A-041. Preprocessed data for Gasterosteus acule *versus time-to-fatigue, where time (t) ≤150 minutes. Blu* *(1986); red triangles are data from Whoriskey and Woott*

Table A-041. Swim speed data summary. Fish count 79,

Variables	Mean	SD	Min
l (m)	0.057	0.007	0.044
T (C)	13.1	5	9.5
U (m/s)*	0.308	0.022	0.264
t_e (s)	2858	3398	60
$t_{\Delta t}$ (s)**	.	.	.

* U=fixed velocity
** t=time step (Δt)

erosteus aculeatus *(Threespine Stickleback): swim speed*
) minutes. Blue squares are data from Taylor and McPhail
key and Wootton (1987).

Fish count 79, record count 9

D	Min	Max	Range	N
07	0.044	0.064	0.02	8
	9.5	20	10.5	2
22	0.264	0.35	0.086	7
3	60	9000	8940	9
	.	.	.	0

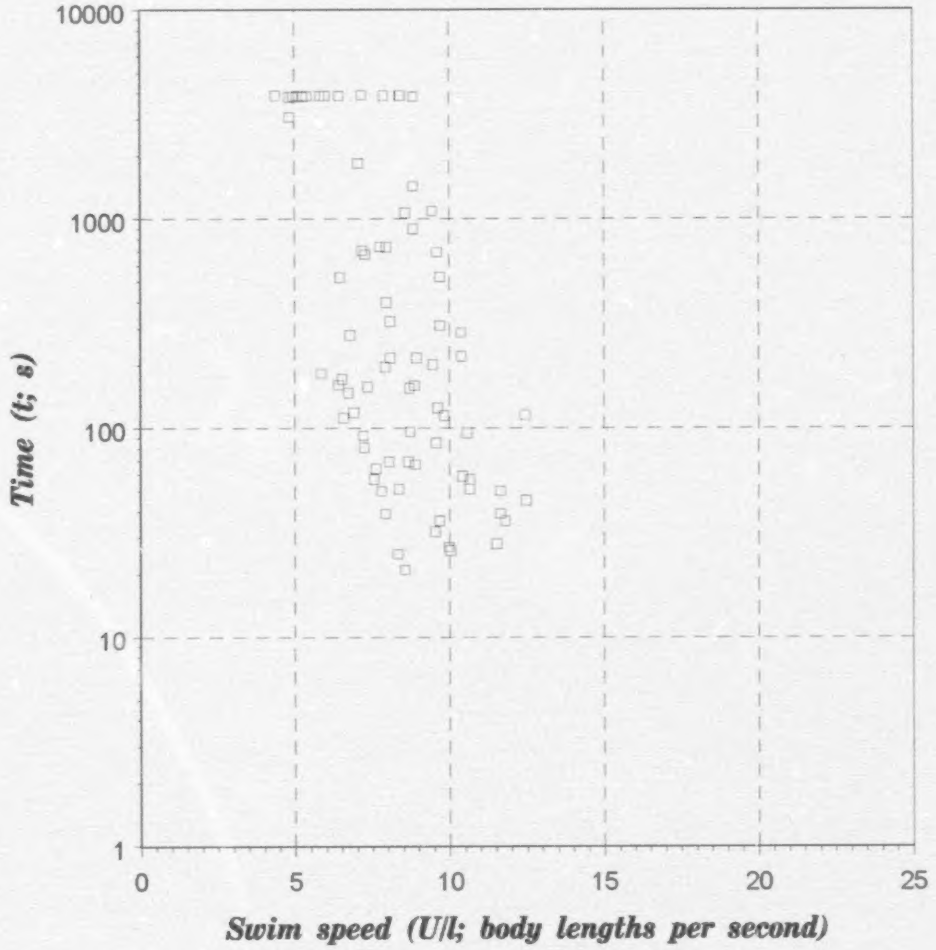


Figure A-042. Preprocessed data for Gasterosteus aculeatus *(Paxton Lake Threespine Stickleback): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Blake et al. (2005).*

Table A-042. Swim speed data summary. Fish count 76, record count 76.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0.006	0.044	0.055	0.011	2
T (C)	15	0	15	15	0	1
U (m/s)*	0.416	0.084	0.242	0.588	0.346	69
t_e (s)	976	1464	21	3912	3891	68
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

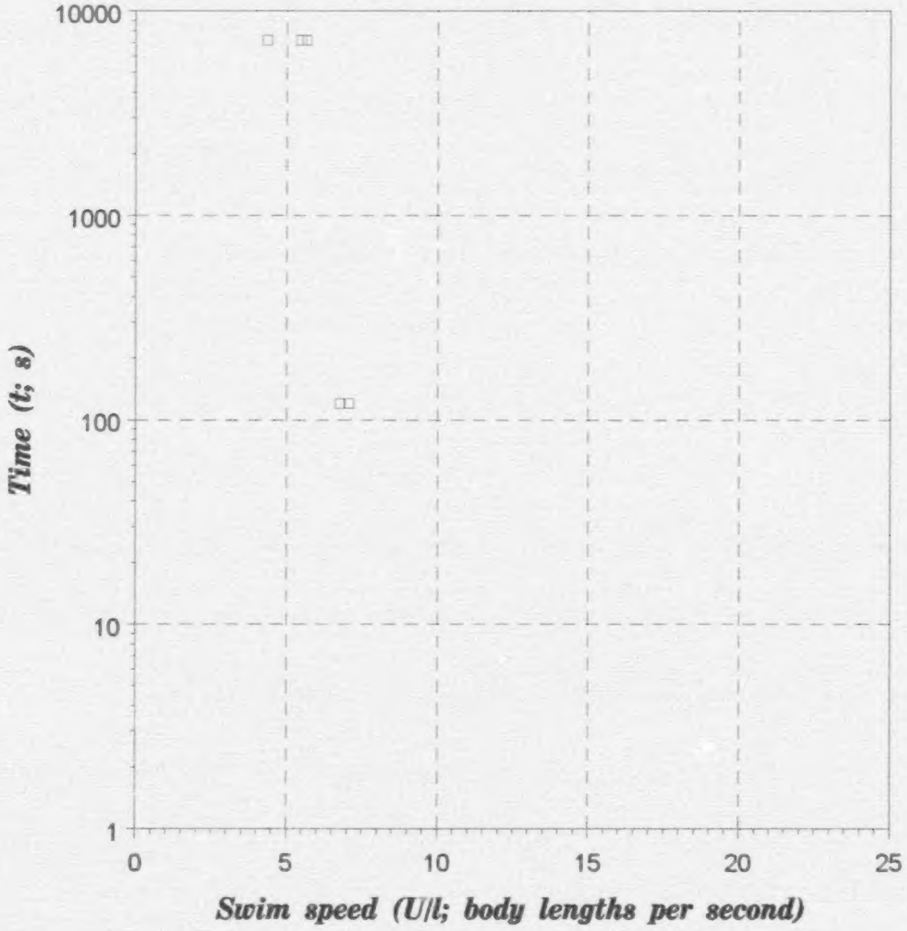


Figure A-043. Preprocessed data for Gila cypha *(Humpback Chub): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Berry and Pimentel (1985).*

Table A-043. Swim speed data summary. Fish count 402, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.095	0.003	0.092	0.099	0.007	3
T (C)	21.2	4.7	14	26	12	3
U (m/s)*	0.557	0.106	0.4	0.7	0.3	5
t_e (s)	4453	3454	120	7200	7080	2
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

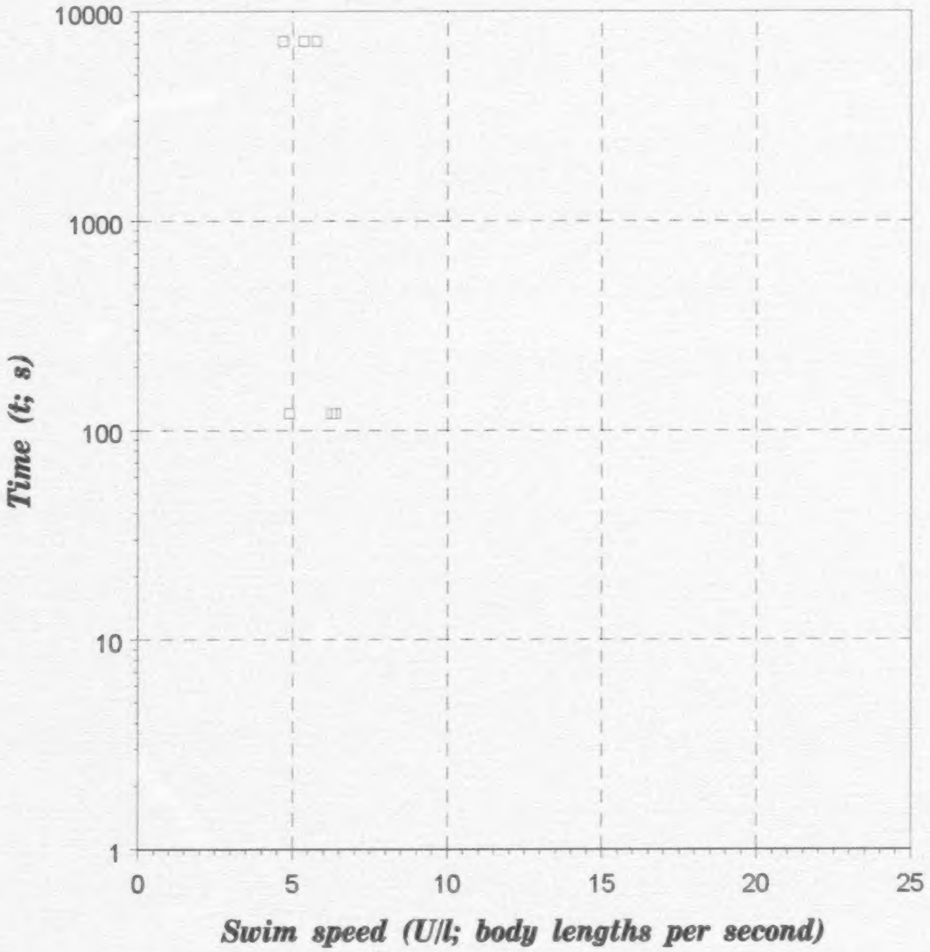


Figure A-044. Preprocessed data for Gila elegans (Bonytail Chub): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Berry and Pimentel (1985).

Table A-044. Swim speed data summary. Fish count 336, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.099	0.001	0.097	0.1	0.003	3
T (C)	20.8	4.8	14	26	12	3
U (m/s)*	0.556	0.058	0.47	0.62	0.15	5
t_e (s)	3660	3545	120	7200	7080	2
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity (U_{crit})
** t=time step (Δt)

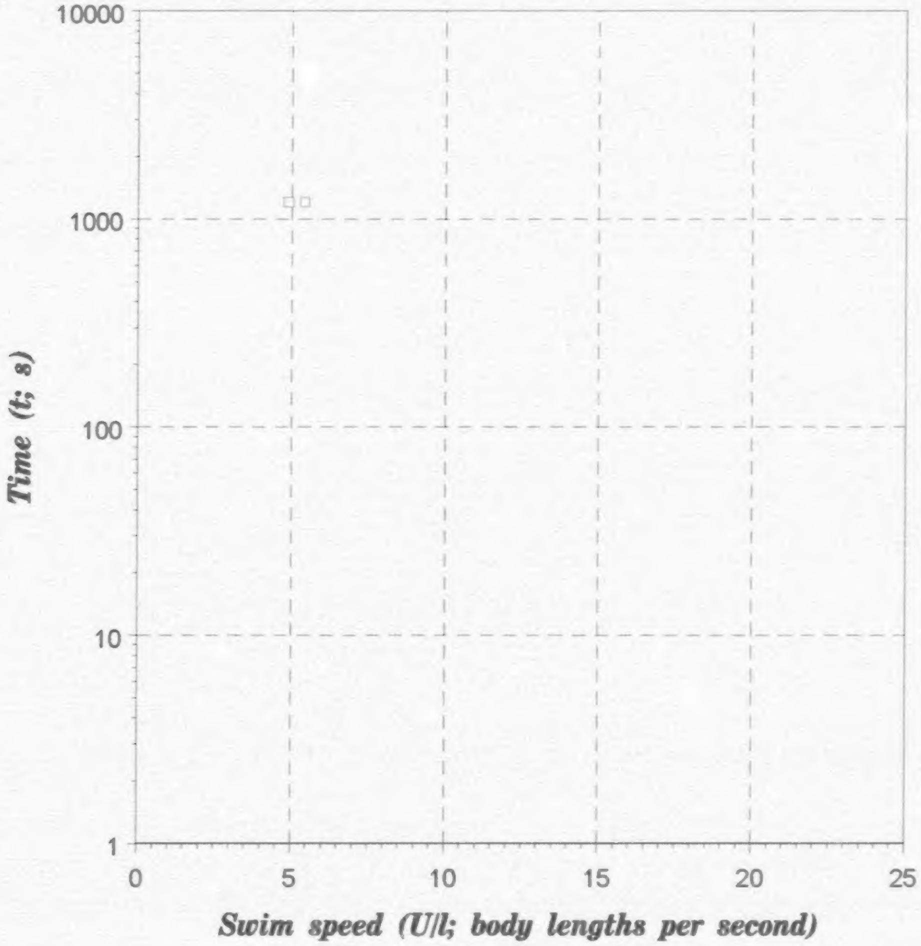


Figure A-045. Preprocessed data for Gobio gobio *(Gudgeon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Tudorache et al. (2008).*

Table A-045. Swim speed data summary. Fish count 16, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.112	0.012	0.1	0.123	0.023	2
T (C)	15	0	15	15	0	1
U (m/s)*	0.572	0.031	0.542	0.602	0.06	2
t_e (s)	-	-	-	-	-	0
$t_{\Delta t}$ (s)**	1200	0	1200	1200	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

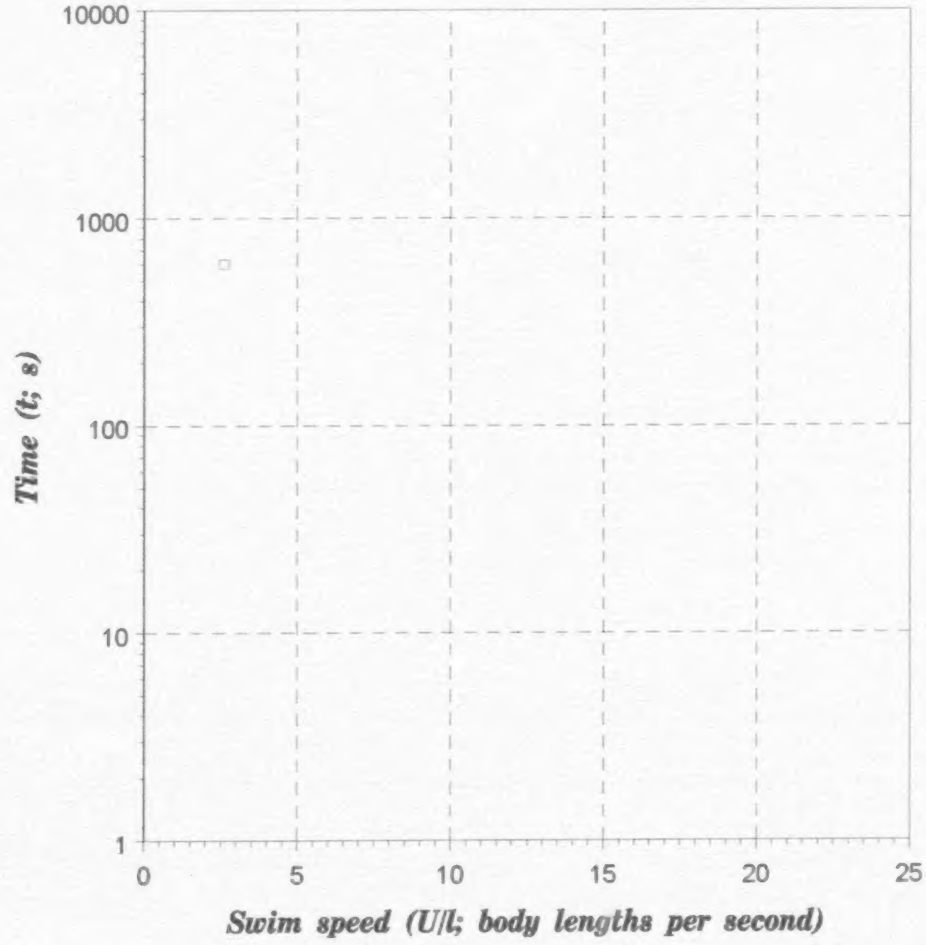


Figure A-046. Preprocessed data for Hiodon alosoides *(Goldeye): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Jones et al. (1973).*

Table A-046. Swim speed data summary. Fish count 2, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.23	0	0.23	0.23	0	1
T (C)	16	0	16	16	0	1
U (m/s)*	.06	0	0.6	0.6	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

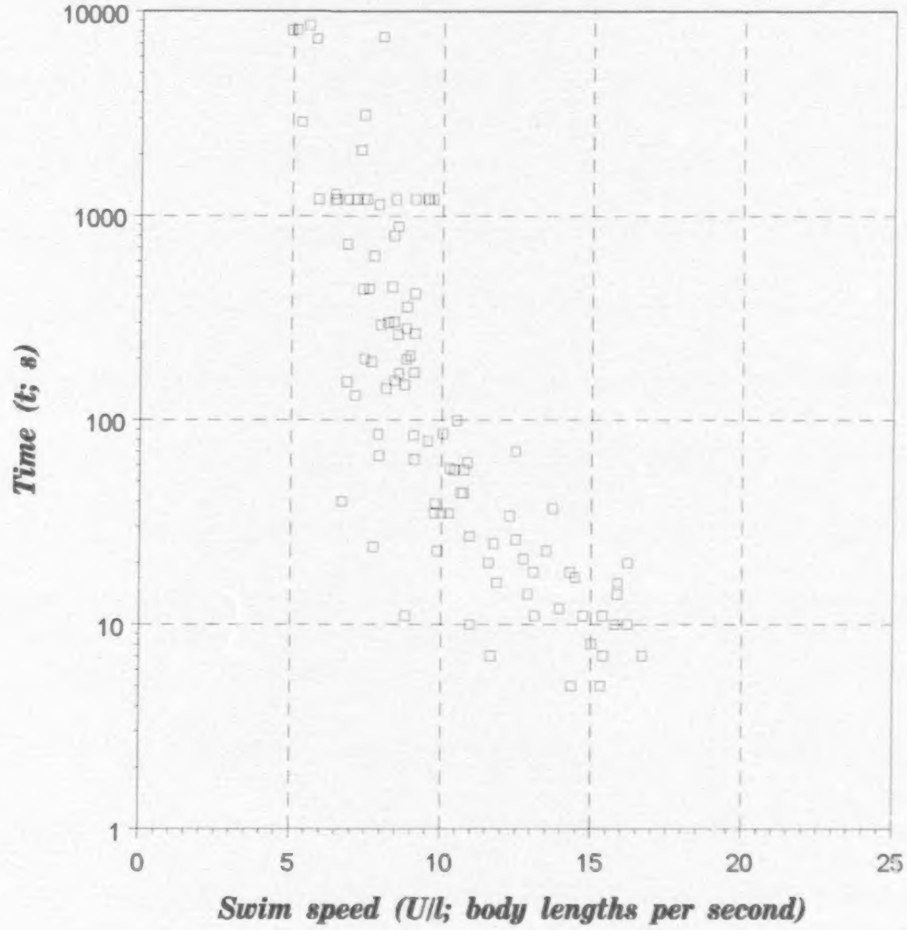


Figure A-047. Preprocessed data for Hybognathus amarus *(Silvery Minnow): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Bestgen et al. (2003).*

Table A-047Swim speed data summary. Fish count 99, record count 99.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.07	0.003	0.053	0.075	0.022	12
T (C)	19.1	3	15	23	8	3
U (m/s)*	0.703	0.217	0.352	1.186	0.834	90
t_e (s)	696	1876	5	8565	8560	70
$t_{\Delta t}$ (s)**	1200	0	1200	1200	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

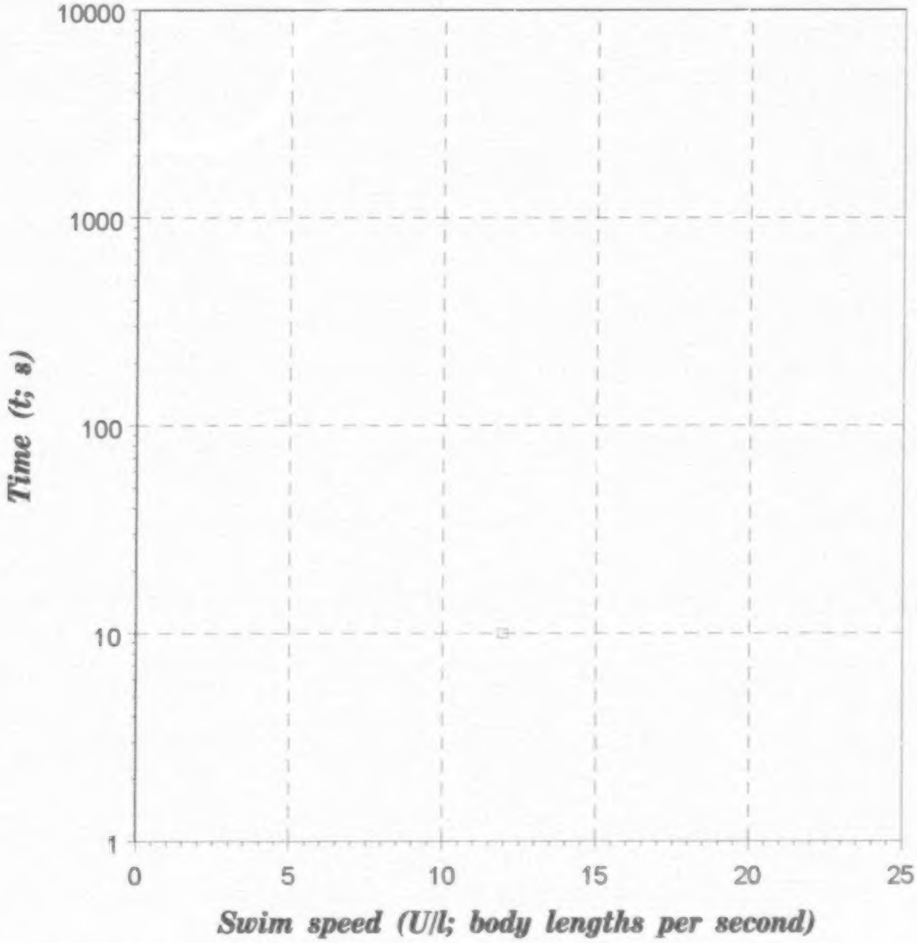


Figure A-048. Preprocessed data for Hybognathus placitus *(Plains Minnow): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-048. Swim speed data summary. Fish count 32, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0	0.51	0.51	0	1
T (C)	28.7	0	28.7	28.7	0	1
U (m/s)*	0.611	0	0.611	0.611	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

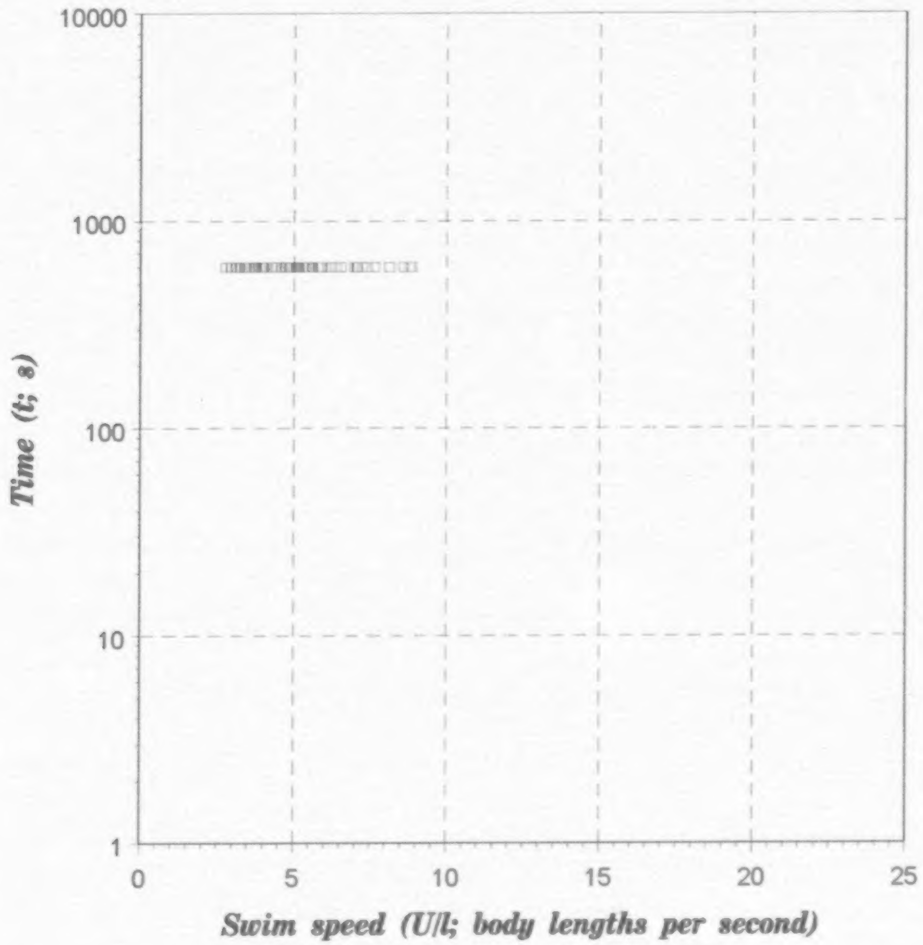


Figure A-049. Preprocessed data for Hypomesus transpacificus *(Delta Smelt): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Swanson and Cech (1995).*

Table A-049. Swim speed data summary. Fish count 71, record count 71.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.055	0.01	0.032	0.073	0.041	31
T (C)	16	3	12	21	9	3
U (m/s)*	0.266	0.048	0.18	0.38	0.2	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

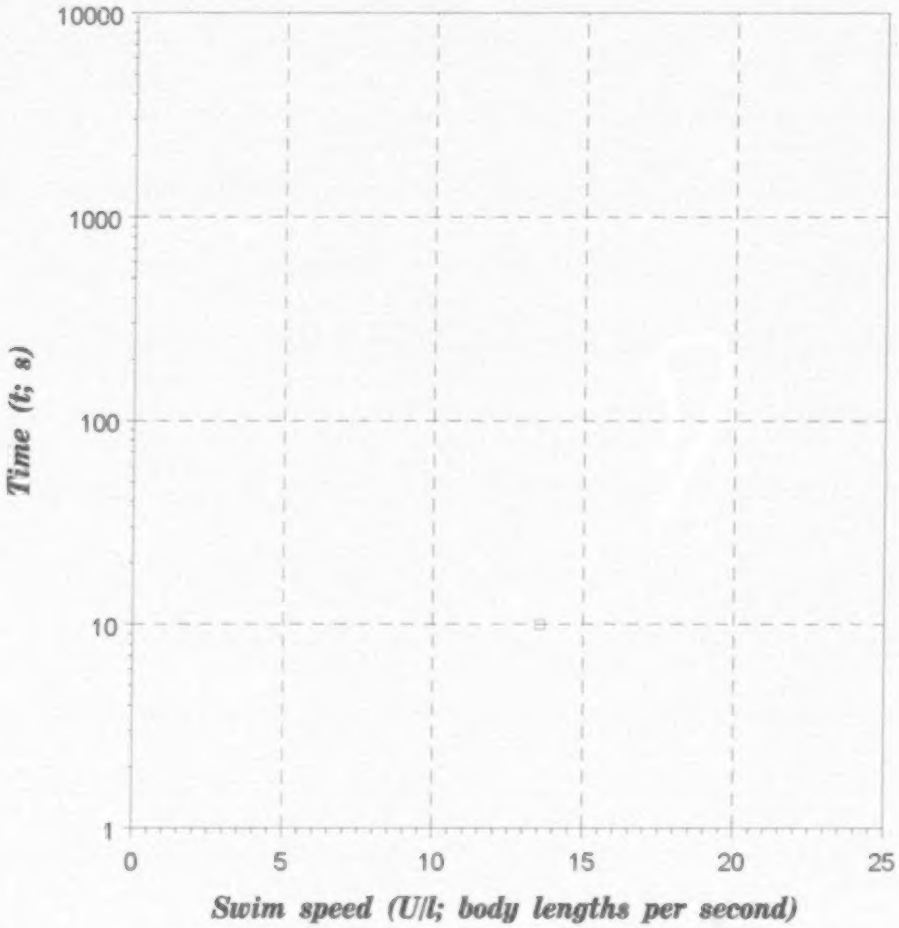


Figure A-050. Preprocessed data for Ictalurus furcatus *(Blue Catfish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-050. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.052	0	0.052	0.052	0	1
T (C)	29.6	0	29.6	29.6	0	1
U (m/s)*	0.7	0	0.7	0.7	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

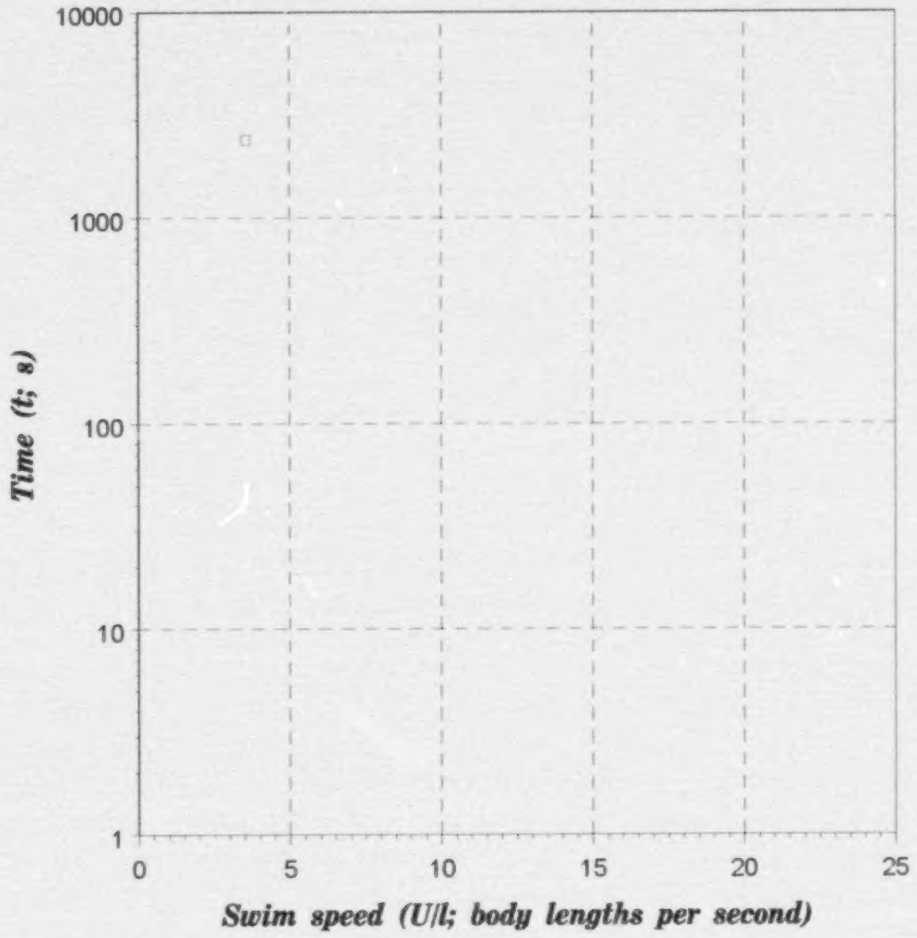


Figure A-051. Preprocessed data for Ictalurus punctatus *(Channel Catfish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Watenpaugh and Beitinger (1985).*

Table A-051. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.105	0	0.105	0.105	0	1
T (C)	30	0	30	30	0	1
U (m/s)*	0.373	0	0.373	0.373	0	1
t_e (s)	2400	0	2400	2400	0	0
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

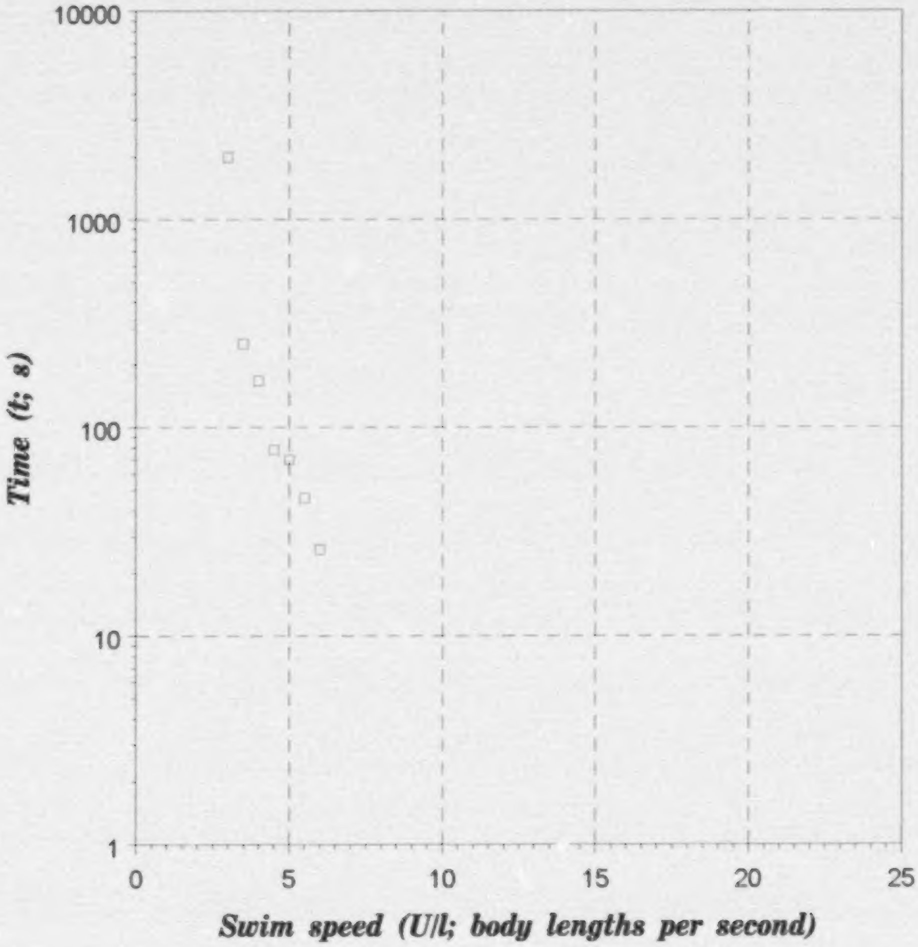


Figure A-052. Preprocessed data for Ictalurus punctatus x furcatus *(channel x blue hybrid): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Beecham et al. (2009).*

Table A-052. Swim speed data summary. Fish count 80, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.2	0	0.2	0.2	0	1
T (C)	20.5	0	20.5	20.5	0	1
U (m/s)*	0.928	0.209	0.6	1.2	0.6	7
t_e (s)	336	634	26	1992	1966	7
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

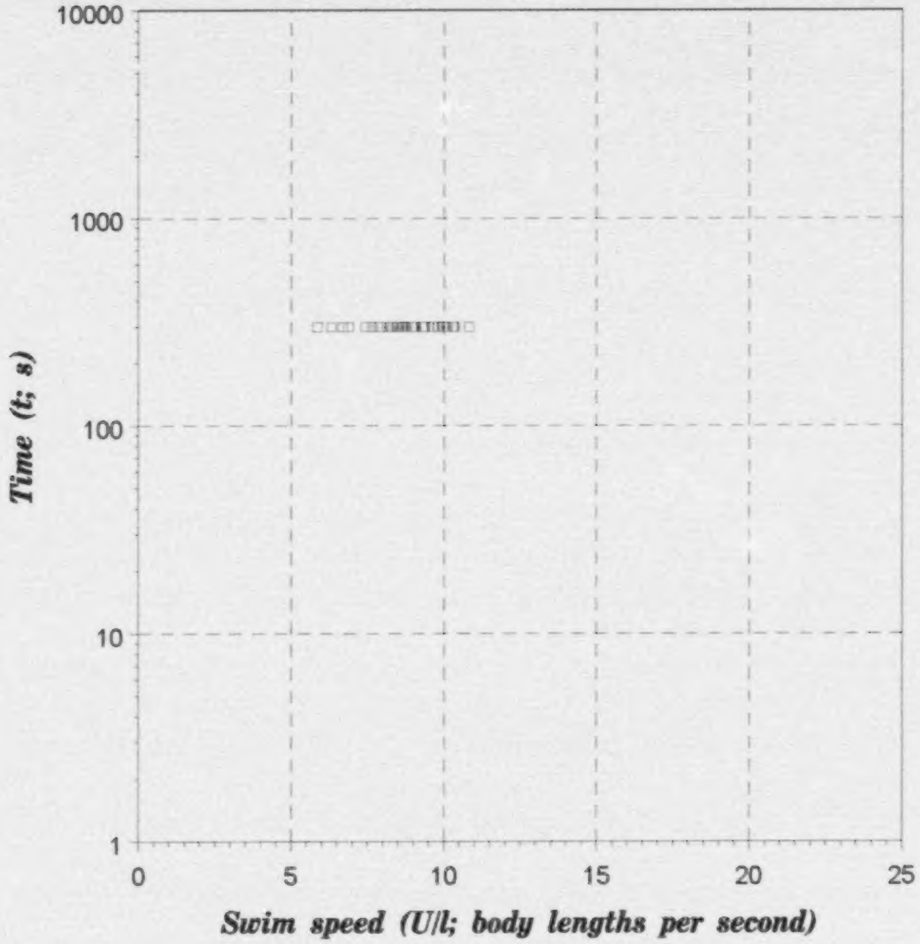


Figure A-053. Preprocessed data for Iotichthys phlegethontis *(Least Chub): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Aedo et al. (2009).*

Table A-053. Swim speed data summary. Fish count 40, record count 40.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.033	0.004	0.024	0.042	0.018	16
T (C)	17	0	17	17	0	1
U (m/s)*	0.286	0.046	0.207	0.379	0.172	30
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

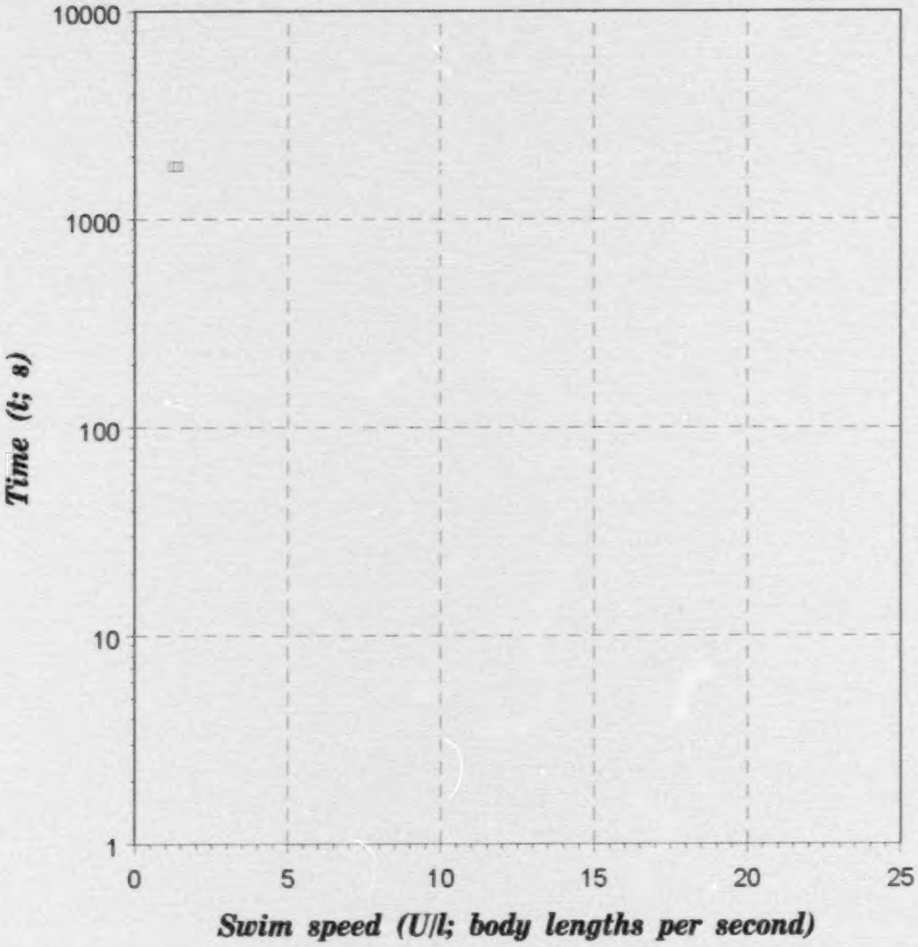


Figure A-054. Preprocessed data for Lampetra tridentata *(Pacific Lamprey): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Mesa et al. (2003a).*

Table A-054. Swim speed data summary. Fish count 24, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.632	0.016	0.623	0.659	0.036	2
T (C)	15	0	15	15	0	1
U (m/s)*	0.862	0.019	0.829	0.873	0.044	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	1800	0	1800	1800	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

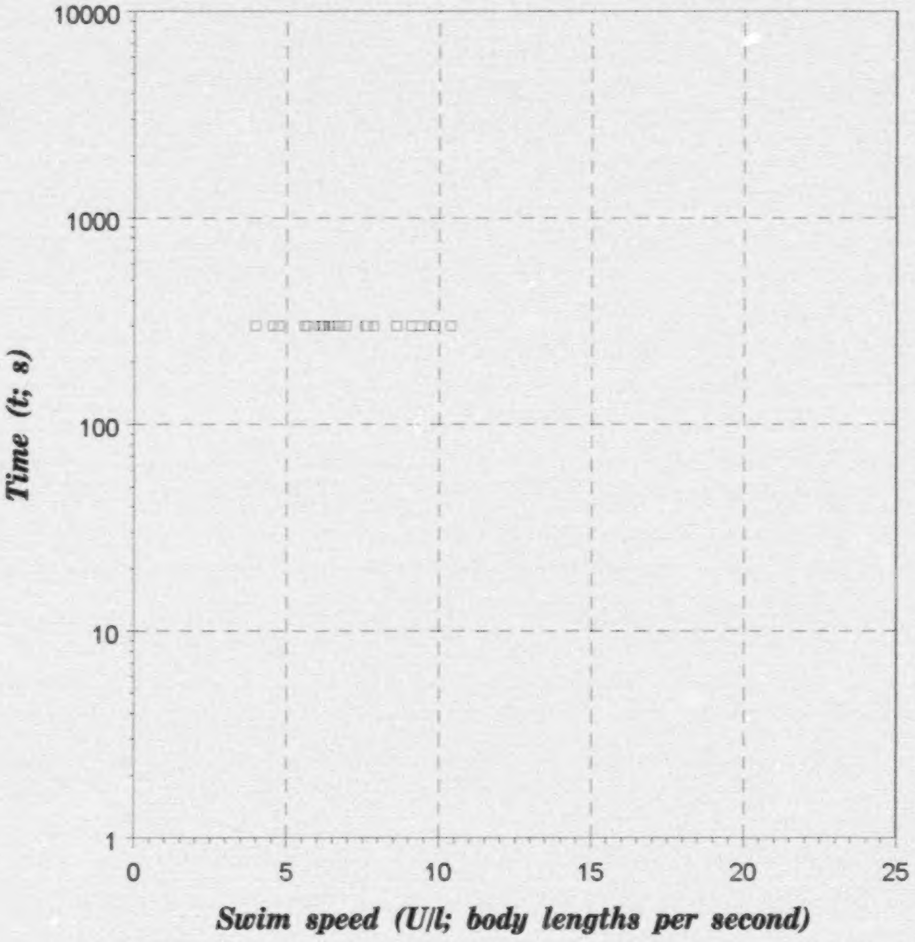


Figure A-055. Preprocessed data for Lepidomeda aliciae *(Southern Leatherside Chub): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Aedo et al. (2009).*

Table A-055. Swim speed data summary. Fish count 21, record count 21.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.078	0.019	0.039	0.107	0.068	18
T (C)	17	0	17	17	0	1
U (m/s)*	0.542	0.172	0.349	0.936	0.587	21
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

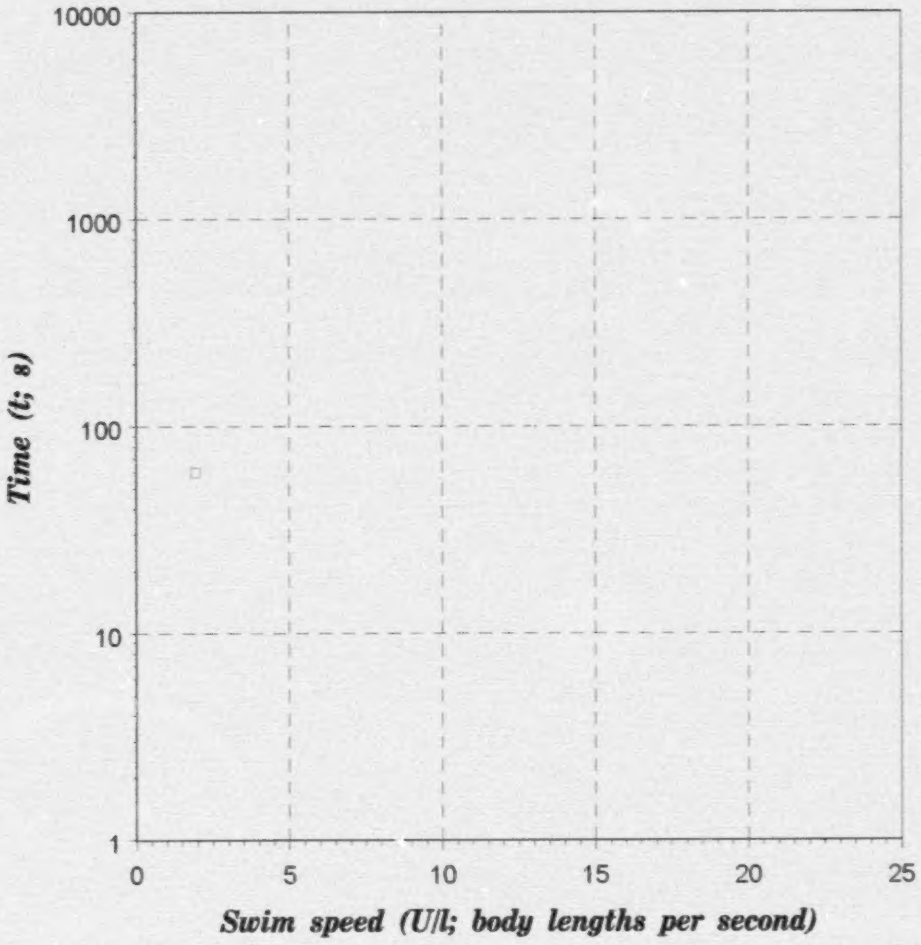


Figure A-056. Preprocessed data for Lepisosteus osseus *(Longnose Gar): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Webb et al. (1992).*

Table A-056. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.266	0	0.266	0.266	0	1
T (C)	25	0	25	25	0	1
U (m/s)*	0.514	0	0.514	0.514	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	60	0	60	60	0	1

* U=fixed velocity
** t=time step (Δt)

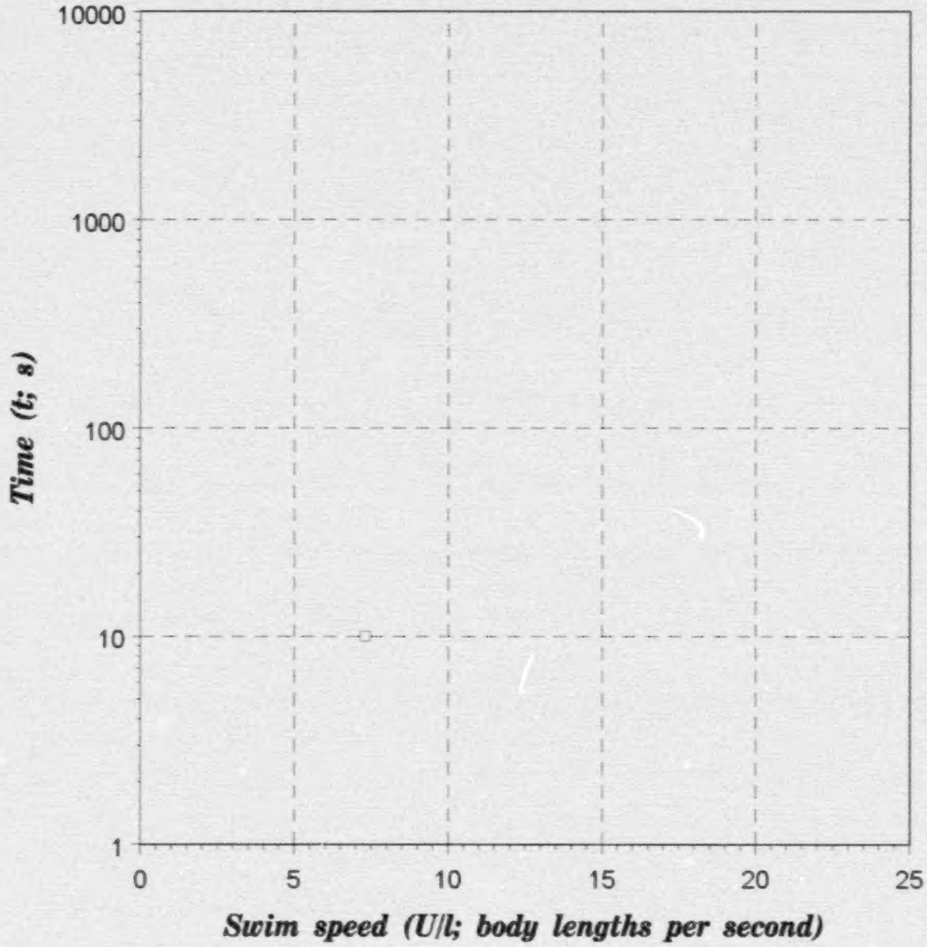


Figure A-057. Preprocessed data for Lepomis auritus *(Redbreast Sunfish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-057. Swim speed data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.048	0	0.048	0.048	0	1
T (C)	26.7	0	26.7	26.7	0	1
U (m/s)*	0.354	0	0.354	0.354	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

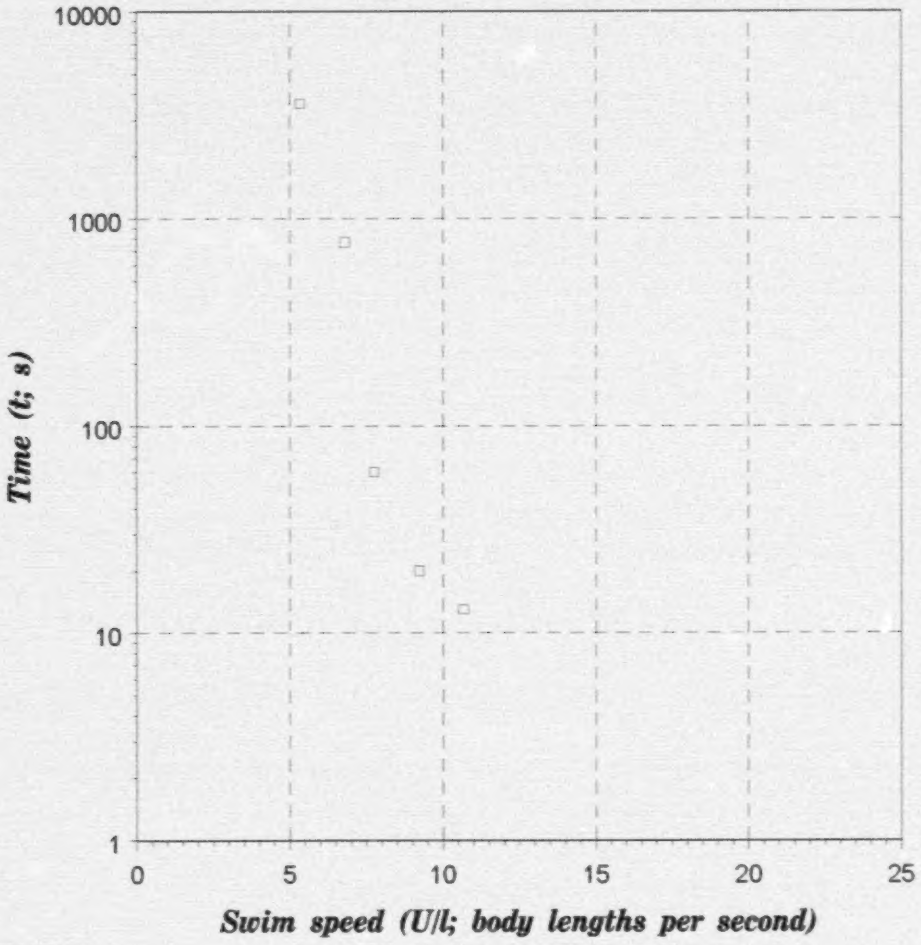


Figure A-058. Preprocessed data for Lepomis incisor *(Sunfish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Tsukamoto et al. (1975).*

Table A-058. Swim speed data summary. Fish count 25, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.103	0	0.103	0.103	0	1
T (C)	22	0	22	22	0	1
U (m/s)*	0.82	0.195	0.55	1.1	0.55	5
t_e (s)	893	1412	13	3600	3587	5
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

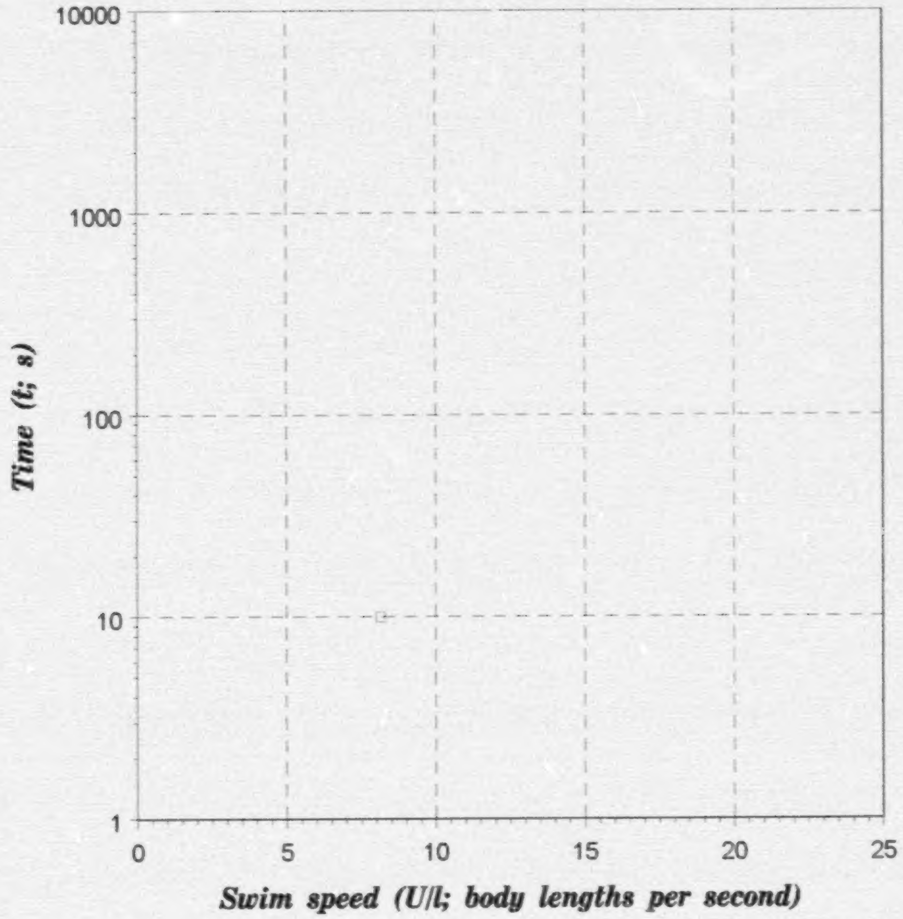


Figure A-059. Preprocessed data for Lepomis macrochirus *(Bluegill): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-059. Swim speed data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.05	0	0.05	0.05	0	1
T (C)	25.3	0	25.3	25.3	0	1
U (m/s)*	0.405	0	0.405	0.405	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

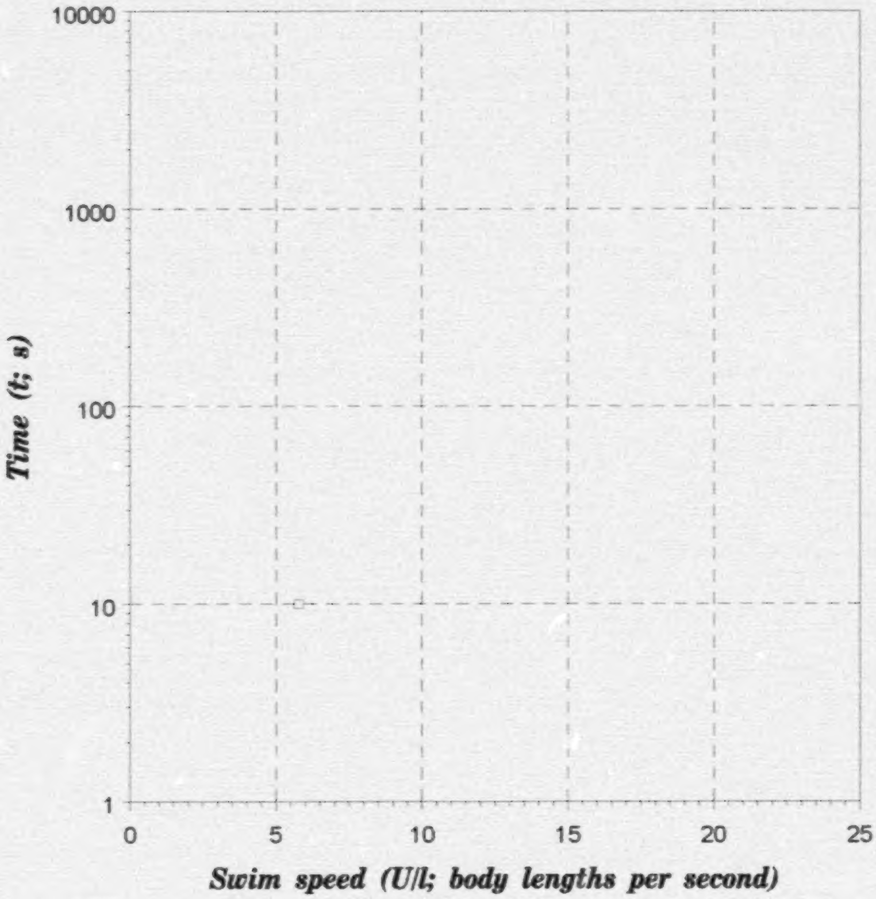


Figure A-060. Preprocessed data for Lepomis megalotis *(Longear Sunfish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-060. Swim speed data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.049	0	0.049	0.049	0	1
T (C)	24.4	0	24.4	24.4	0	1
U (m/s)*	0.28	0	0.28	0.28	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

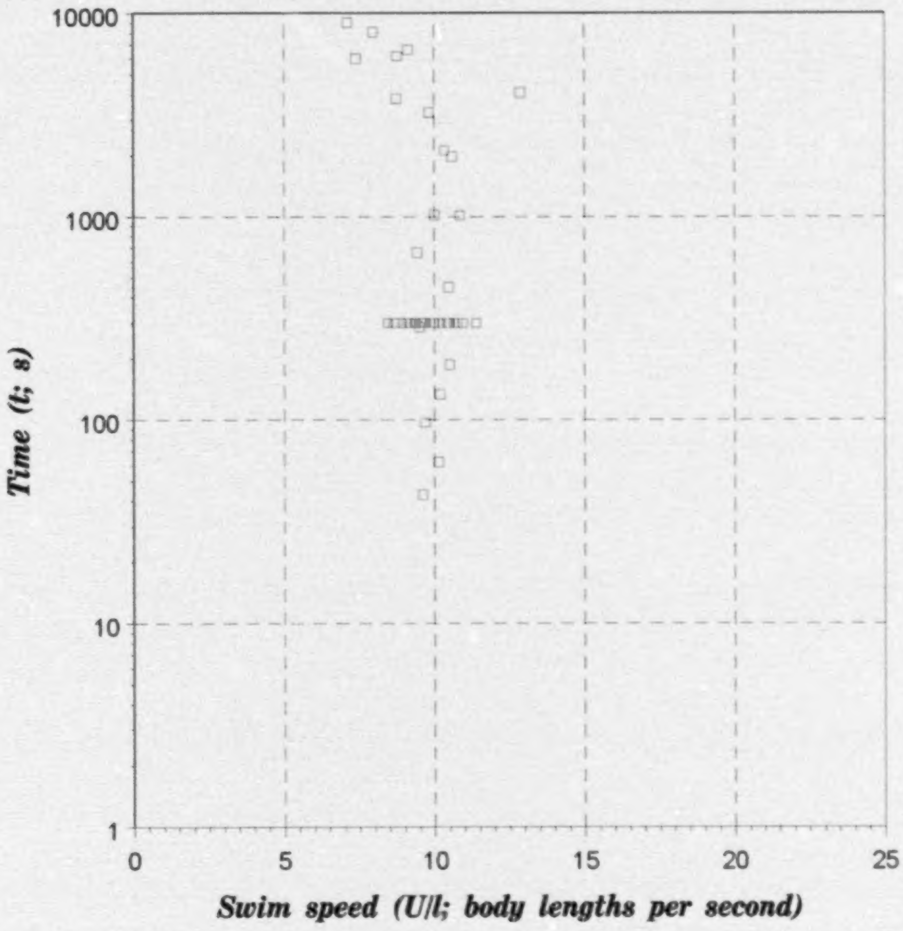


Figure A-061. Preprocessed data for Leporinus reinhardti *(Piau Tres Pintas): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Santos et al. (2007).*

Table A-061. Swim speed data summary. Fish count 45, record count 45.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.152	0.015	0.125	0.185	0.06	17
T (C)	26.5	0.6	25.1	28	2.9	17
U (m/s)*	1.465	0.156	0.96	1.743	0.783	41
t_e (s)	2753	2952	43	9000	8957	20
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

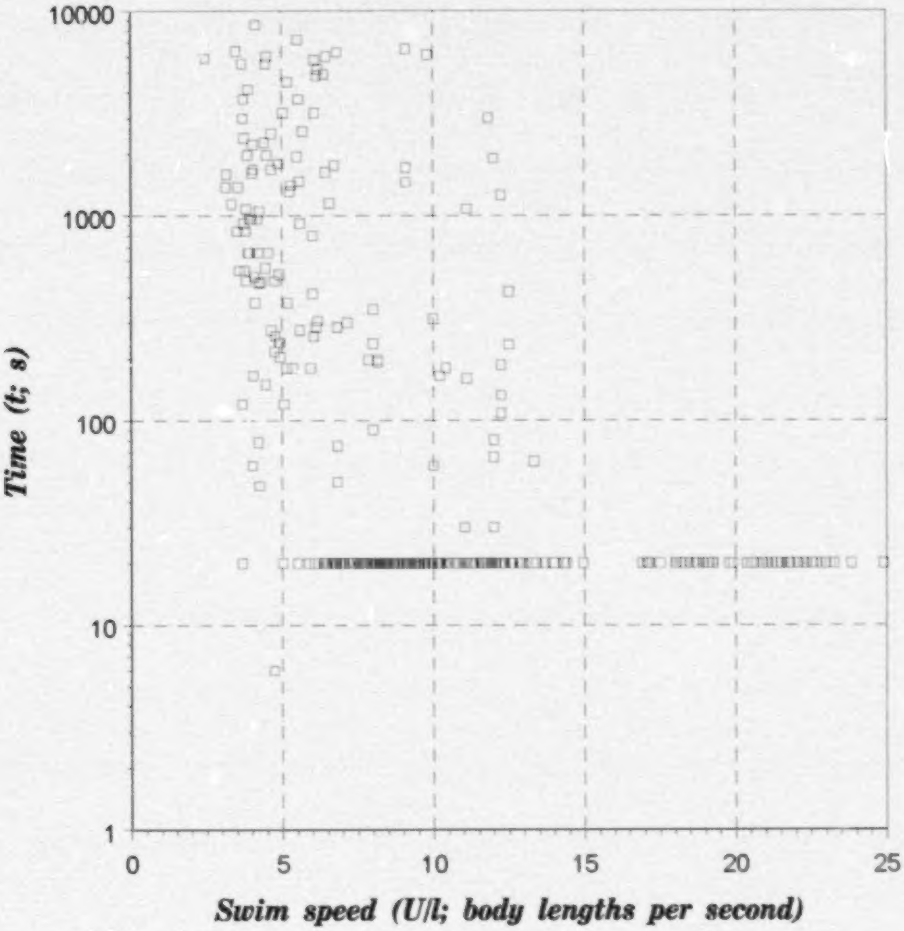


Figure A-062. Preprocessed data for Leuciscus cephalus *(European Chub): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Clough and Turnpenny (2000).*

Table A-062. Swim speed data summary. Fish count 352, record count 352.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.128	0.054	0.044	0.28	0.236	130
T (C)	13.6	4.2	6.8	20.8	14	35
U (m/s)*	1.073	0.367	0.3	1.963	1.663	146
t_e (s)	1537	1946	6	8580	8574	95
$t_{\Delta t}$ (s)**	20	0	20	20	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

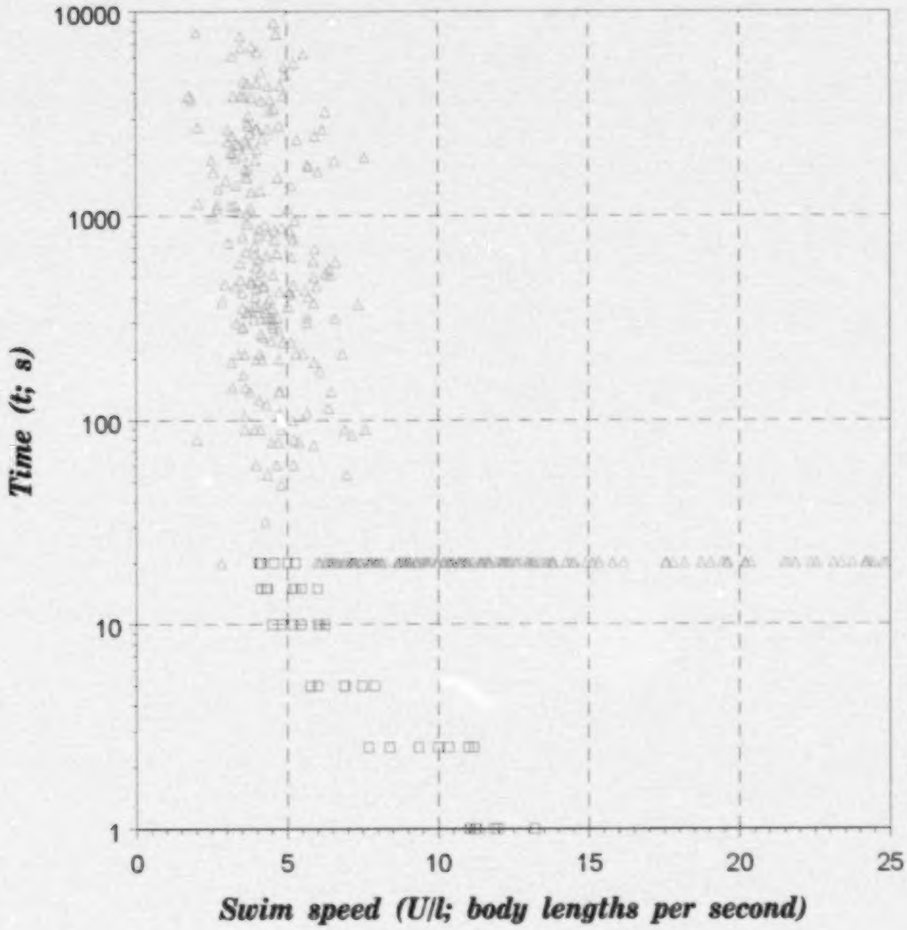


Figure A-063. Preprocessed data for Leuciscus leuciscus *(Dace): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Bainbridge (1960); red triangles are data from Clough and Turnpenny (2000).*

Table A-063. Swim speed data summary. Fish count 474, record count 474.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.142	0.047	0.038	0.24	0.202	133
T (C)	14.5	4.8	4.1	21.1	17	31
U (m/s)*	0.987	0.414	0.288	2.4	2.112	167
t_e (s)	1168	1666	1	8784	8783	167
$t_{\Delta t}$ (s)**	20	0	20	20	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

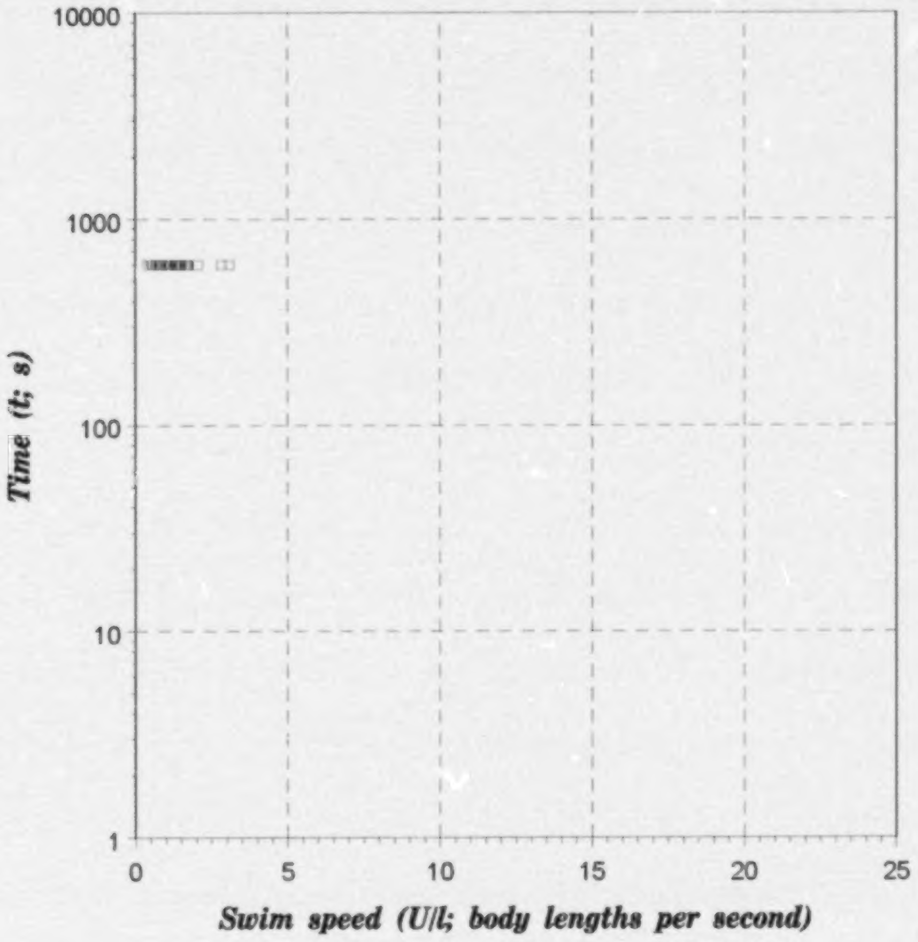


Figure A-064. Preprocessed data for Lota lota *(Burbot): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973).*

Table A-064. Swim speed data summary. Fish count 52, record count 52.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.393	0.123	0.12	0.63	0.51	32
T (C)	10	0	10	10	0	1
U (m/s)*	0.396	0.081	0.2	0.52	0.32	23
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

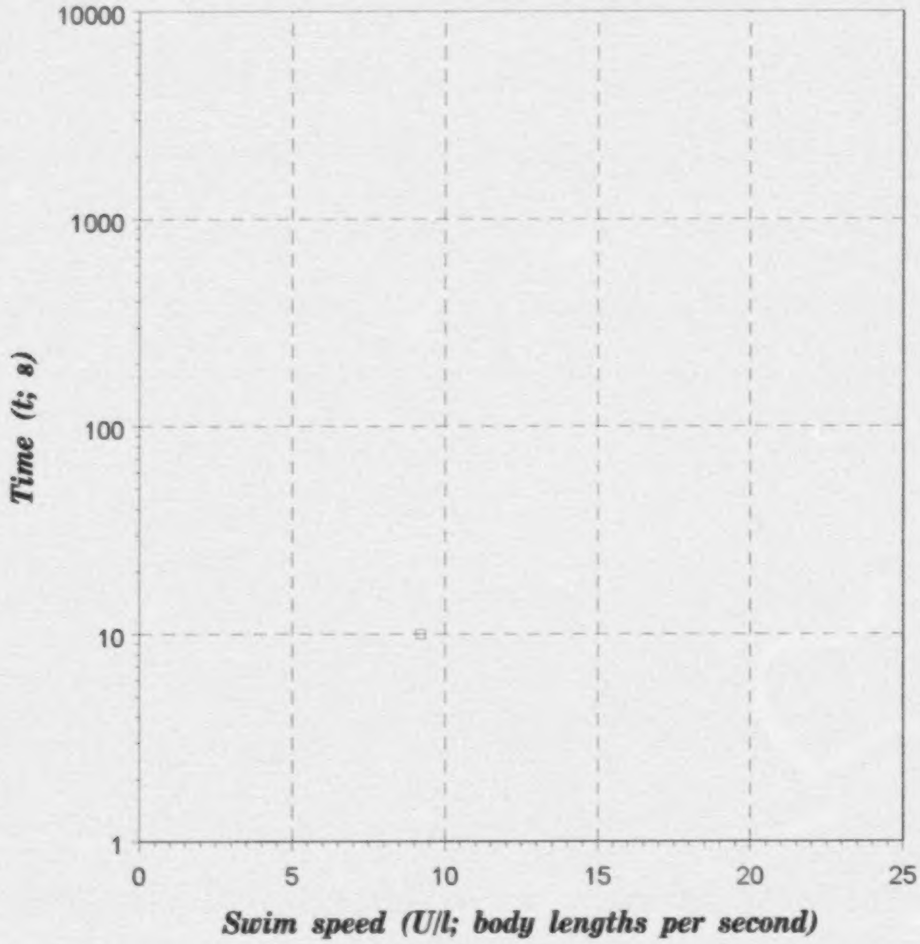


Figure A-065. Preprocessed data for Luxilus chrysocephalus *(Striped Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-065. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.044	0	0.044	0.044	0	1
T (C)	27.5	0	27.5	27.5	0	1
U (m/s)*	0.403	0	0.403	0.403	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

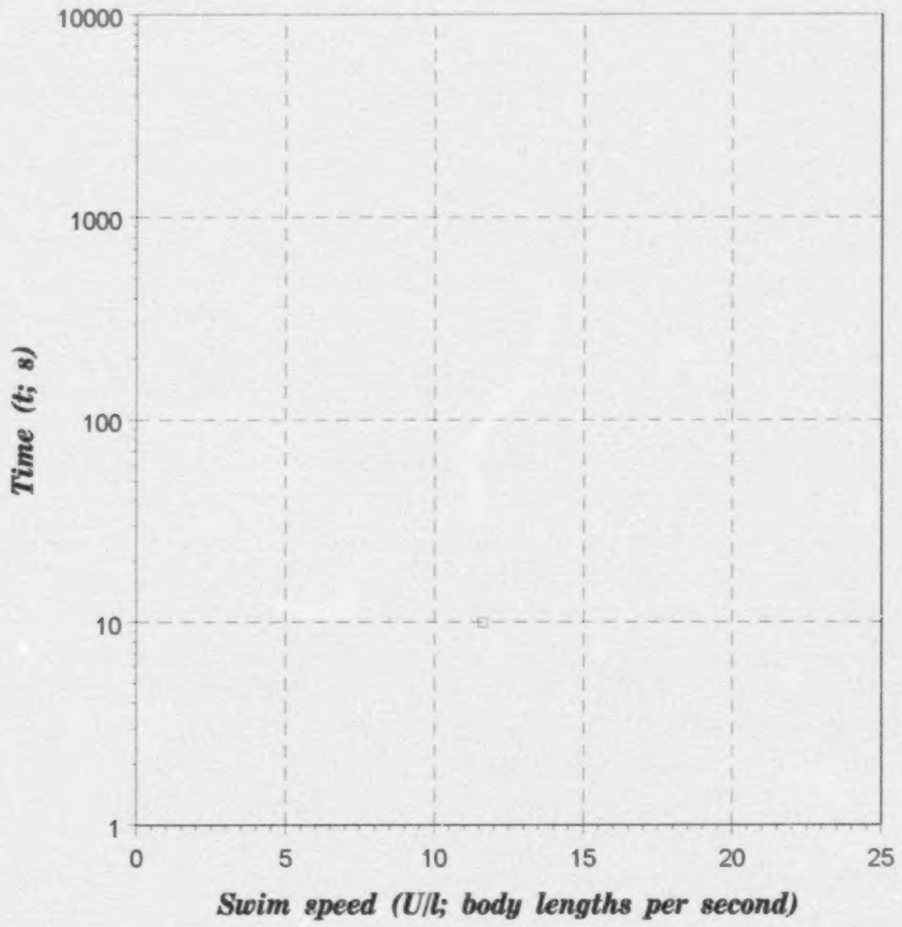


Figure A-066. Preprocessed data for Lythrurus fumeus *(Ribbon Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-066. Swim speed data summary. Fish count 11, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.033	0	0.033	0.033	0	1
T (C)	27.2	0	27.2	27.2	0	1
U (m/s)*	0.381	0	0.381	0.381	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

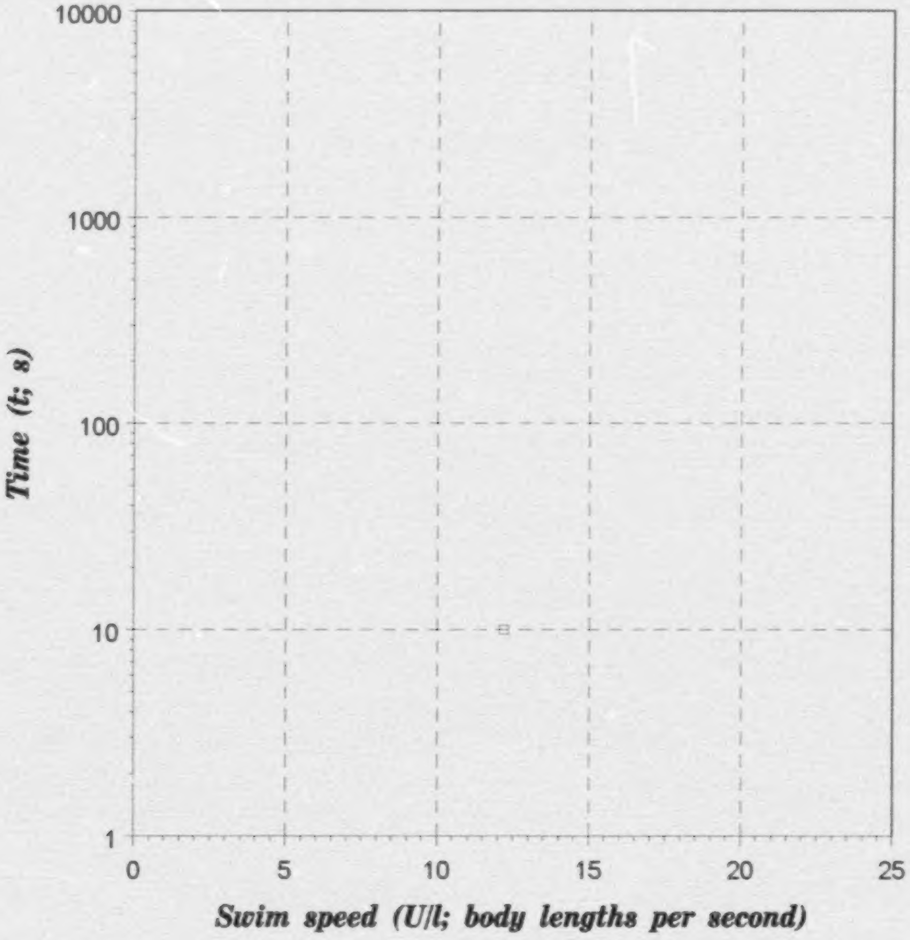


Figure A-067. Preprocessed data for Lythrurus umbratilis *(Redfin Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-067. Swim speed data summary. Fish count 13, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.045	0	0.045	0.045	0	1
T (C)	29	0	29	29	0	1
U (m/s)*	0.55	0	0.55	0.55	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

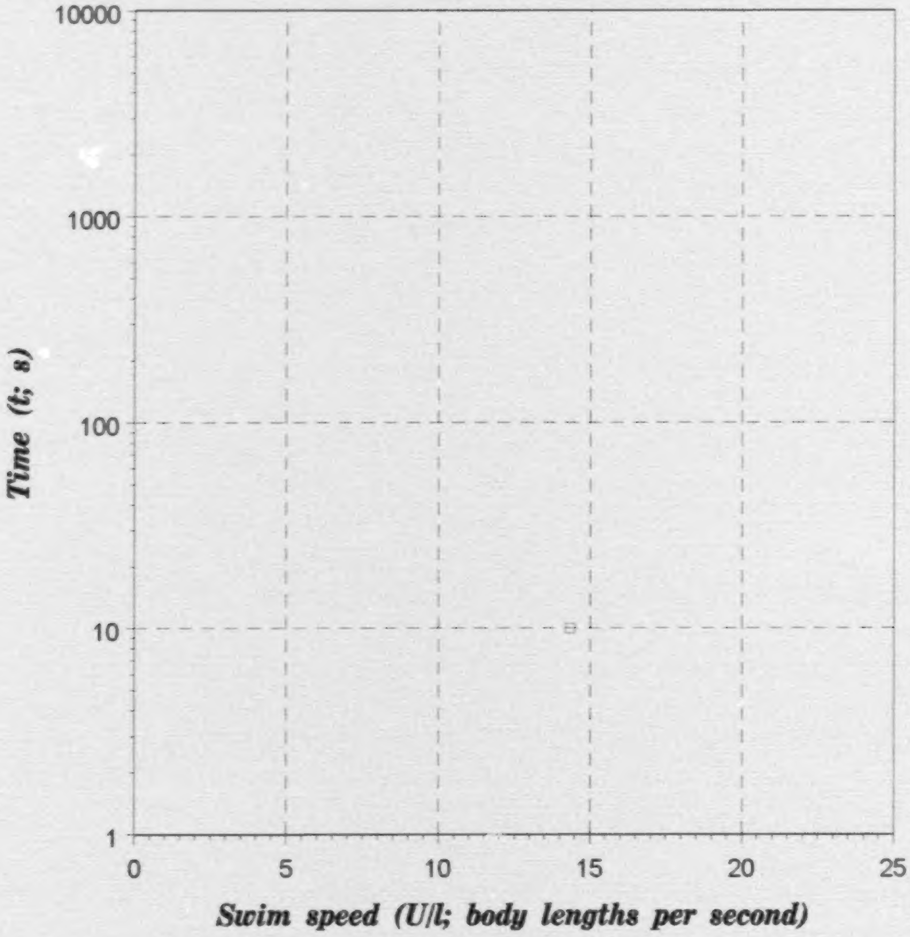


Figure A-068. Preprocessed data for Macrhybopsis aestivalis *(Speckled Chub): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-068. Swim speed data summary. Fish count 11, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	25.3	0	25.3	25.3	0	1
U (m/s)*	0.619	0	0.619	0.619	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

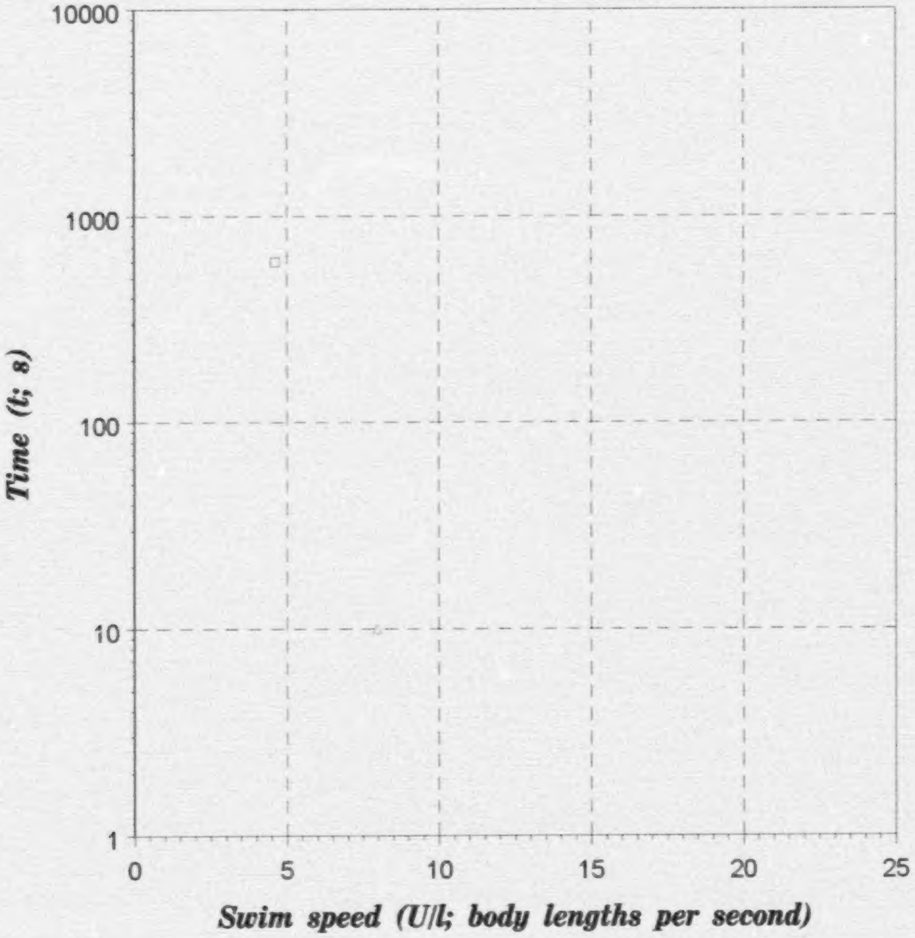


Figure A-069. Preprocessed data for Menidia beryllina *(Inland Silverside): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Swanson and Cech (1995); red triangle is data from Leavy and Bonner (2009).*

Table A-069. Swim speed data summary. Fish count 26, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.056	0.013	0.038	0.065	0.27	2
T (C)	22.1	7.1	17	31.7	14.7	2
U (m/s)*	0.301	0.001	0.3	0.302	0.002	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	396	286	10	600	590	2

* U=critical velocity (U_{crit})
** t=time step (Δt)

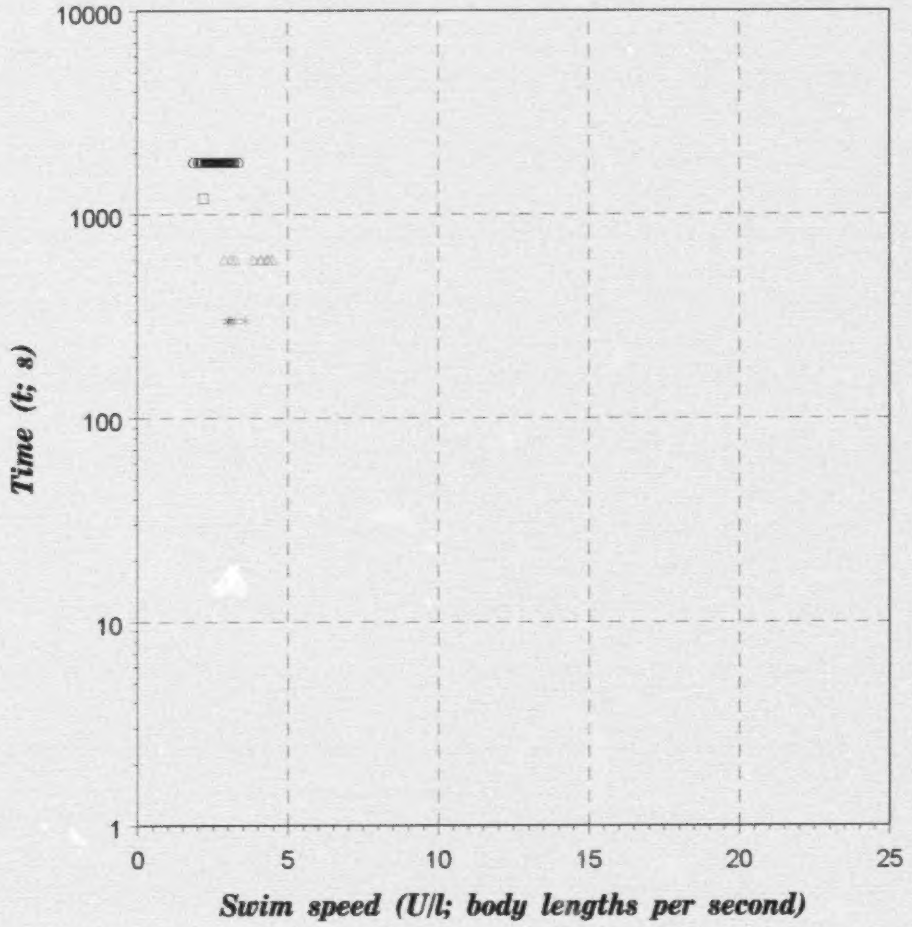


Figure A-070. Preprocessed data for Micropterus dolomieu *(Smallmouth Bass): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from McDonald et al. (1991); red triangles are data from Bunt et al. (1999); green stars are data from Cooke and Bunt (2001); black circles are data from Peake (2004a).*

Table A-070. Swim speed data summary. Fish count 117, record count 67.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0.064	0.123	0.44	0.317	39
T (C)	18.2	1.5	13.5	21	7.5	9
U (m/s)*	0.879	0.178	0.271	1.18	0.909	48
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	1026	713	300	1800	1500	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

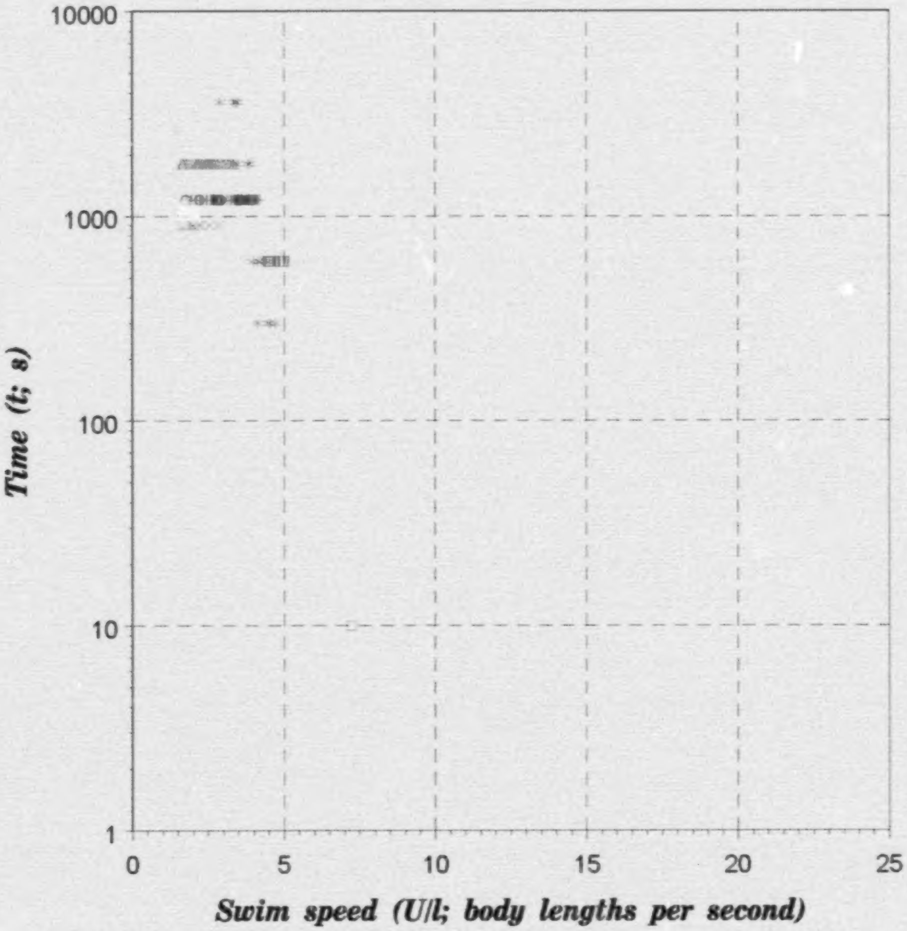


Figure A-071. Preprocessed data for Micropterus salmoides *(Largemouth Bass): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Dalberg et al. (1968); red triangles are data from Beamish (1970); green stars are data from Farlinger and Beamish (1977); black circles are data from Kolok (1991); turquoise diamonds are data from Kolok (1992a); blue crosses are data from Kolok (1992b); red x's are data from Cooke et al. (2001); black squares are data from Leavy and Bonner (2009).*

Table A-071. Swim speed data summary. Fish count 708, record count 169.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.123	0.045	0.032	0.27	0.238	32
T (C)	17.9	8	5	34	29	15
U (m/s)*	0.356	0.105	0.15	0.668	0.518	140
t_e (s)	3840	1240	2622	5088	2466	2
$t_{\Delta t}$ (s)**	1274	762	10	3600	3590	7

* U=critical velocity (U_{crit})
** t=time step (Δt)

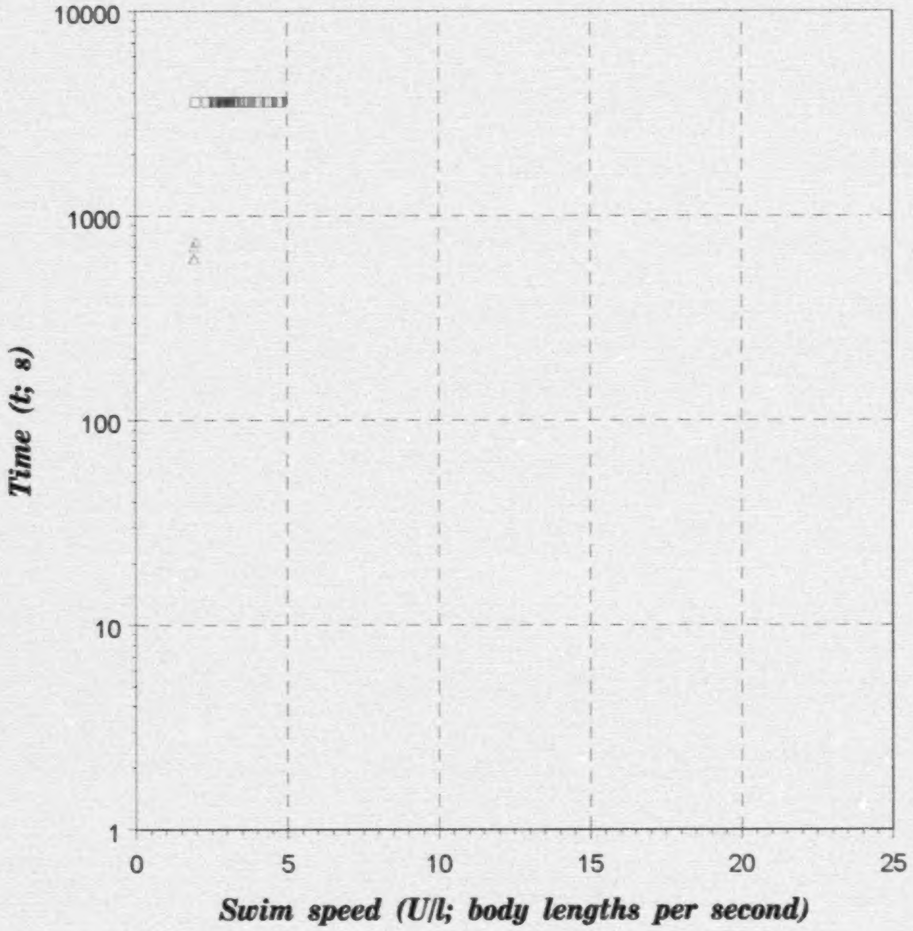


Figure A-072. Preprocessed data for Morone americana *(White Perch): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Griffiths (1979); red triangles are data from Mellas and Haynes (1985).*

Table A-072. Swim speed data summary. Fish count 152, record count 56.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.224	0.06	0.76	0.267	0.191	45
T (C)	17.6	5.5	10	21.5	11.5	2
U (m/s)*	0.497	0.037	0.367	0.575	0.208	45
t_e (s)	671	55	618	744	126	3
$t_{\Delta t}$ (s)**	3600	0	3600	3600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

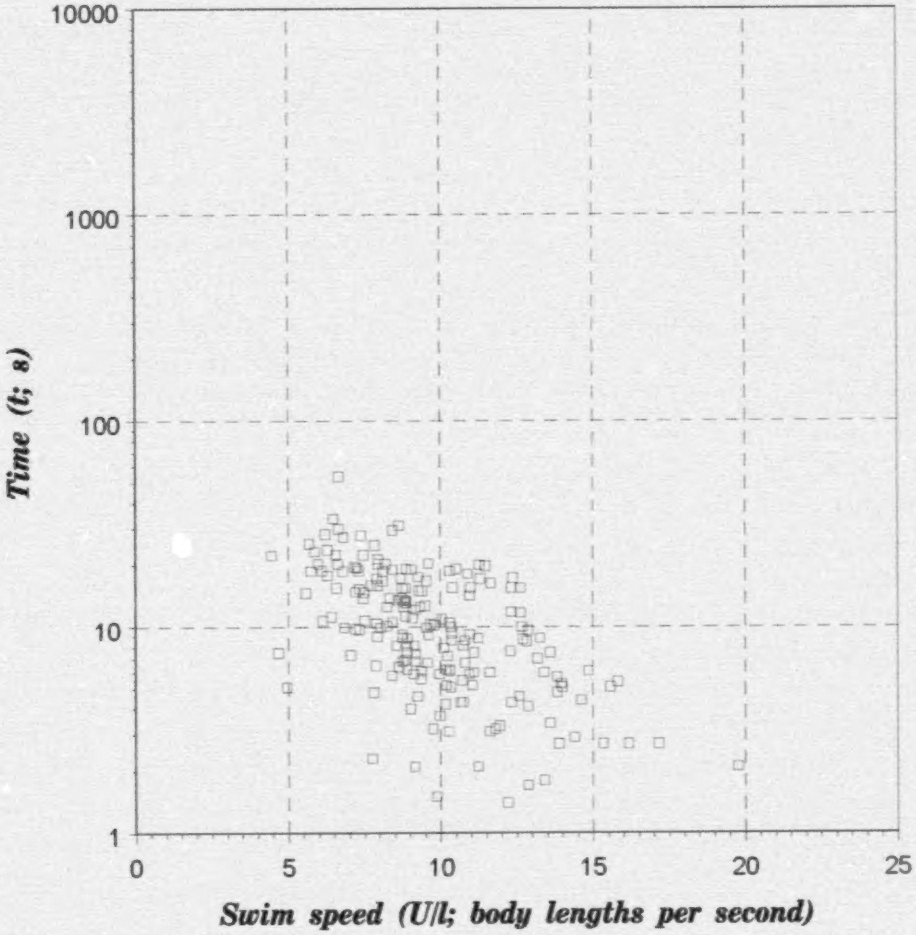


Figure A-073. Preprocessed data for Morone saxatilis *(Striped Bass): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Castro-Santos. (2005).*

Table A-073. Swim speed data summary. Fish count 185, record count 185.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.478	0	0.478	0.478	0	1
T (C)	18.9	0	18.9	18.9	0	1
U (m/s)*	4.66	1.216	2.13	9.45	7.32	143
t_e (s)	12	8	1	54	52	123
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

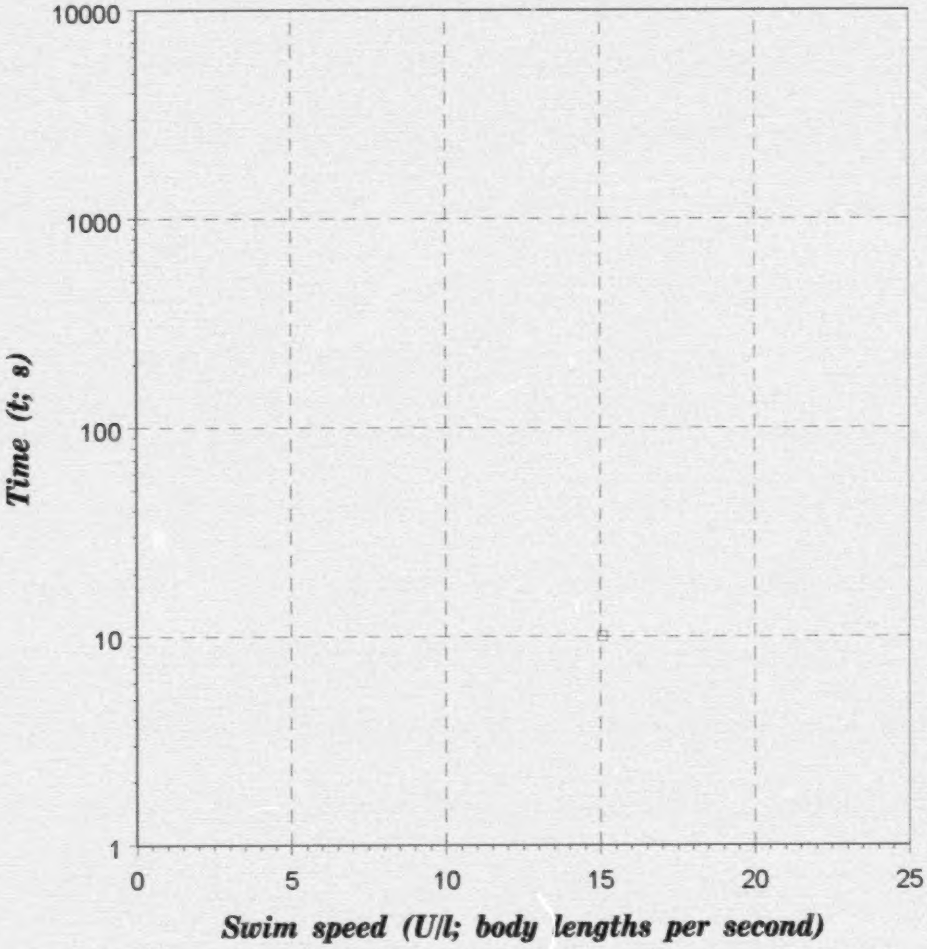


Figure A-074. Preprocessed data for Notropis amabilis *(Texas Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-074. Swim speed data summary. Fish count 29, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.42	0	1
T (C)	23.4	0	23.4	23.4	0	1
U (m/s)*	0.636	0	0.636	0.636	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

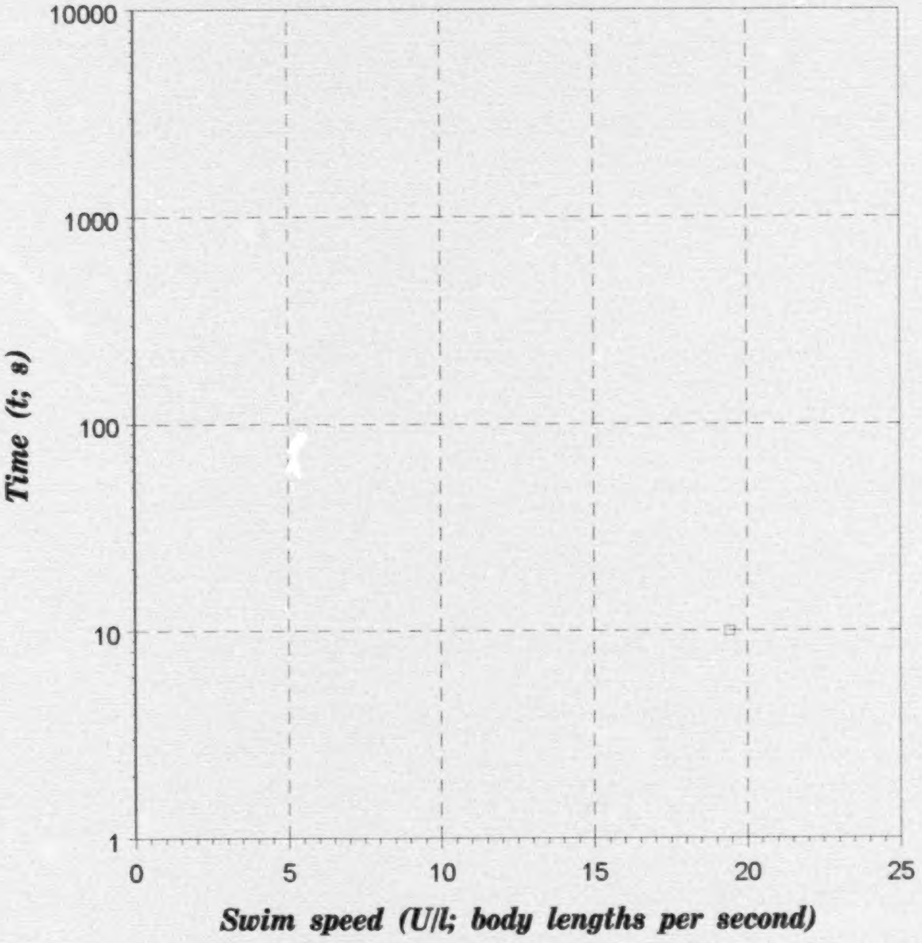


Figure A-075. Preprocessed data for Notropis atherinoides *(Emerald Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-075. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.042	0	1
T (C)	30	0	30	30	0	1
U (m/s)*	0.814	0	0.814	0.814	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

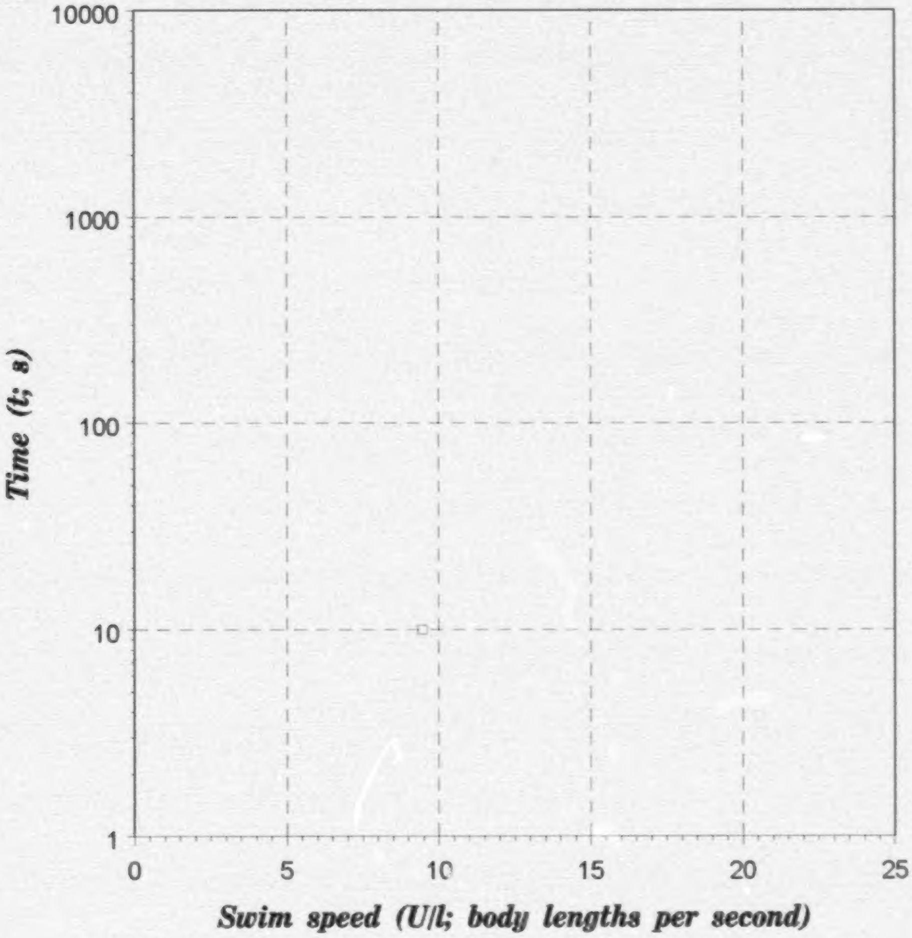


Figure A-076. Preprocessed data for Notropis atrocaudalis *(Blackspot Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-076. Swim speed data summary. Fish count 11, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.05	0	0.05	0.05	0	1
T (C)	26.7	0	26.7	26.7	0	1
U (m/s)*	0.469	0	0.469	0.469	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

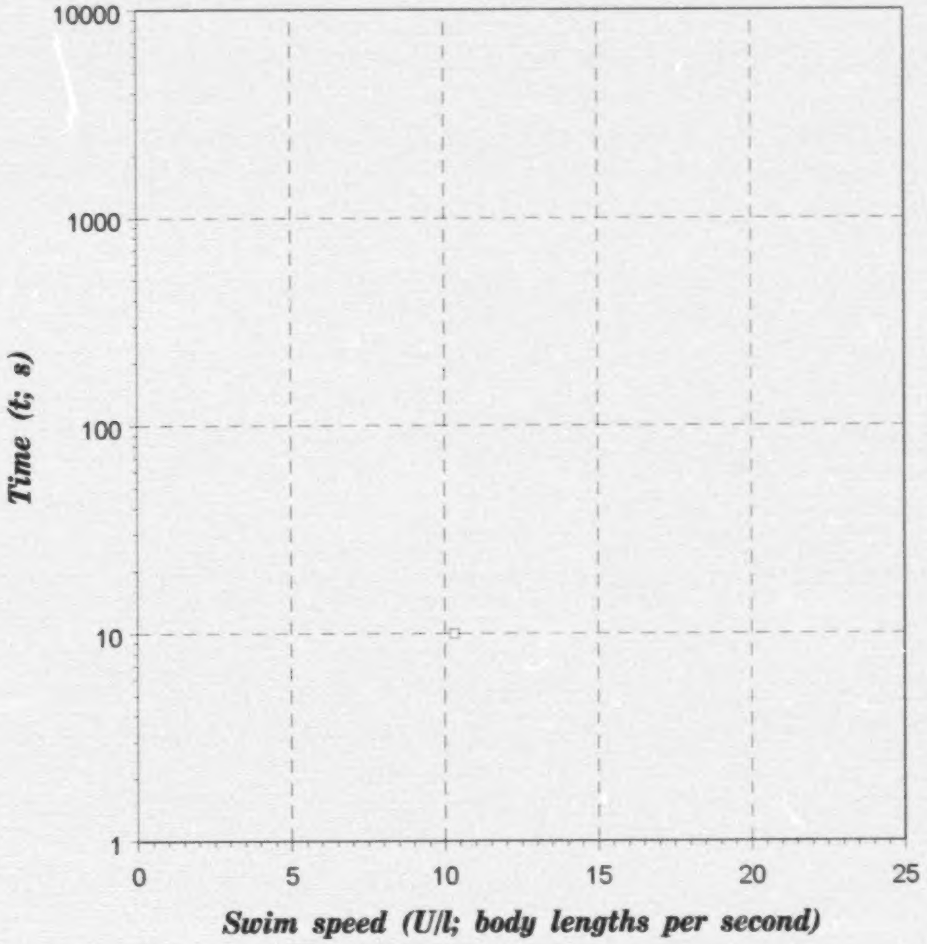


Figure A-077. Preprocessed data for Notropis bairdi *(Red River Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-077. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.044	0	0.044	0.044	0	1
T (C)	25.8	0	25.8	25.8	0	1
U (m/s)*	0.456	0	0.456	0.456	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

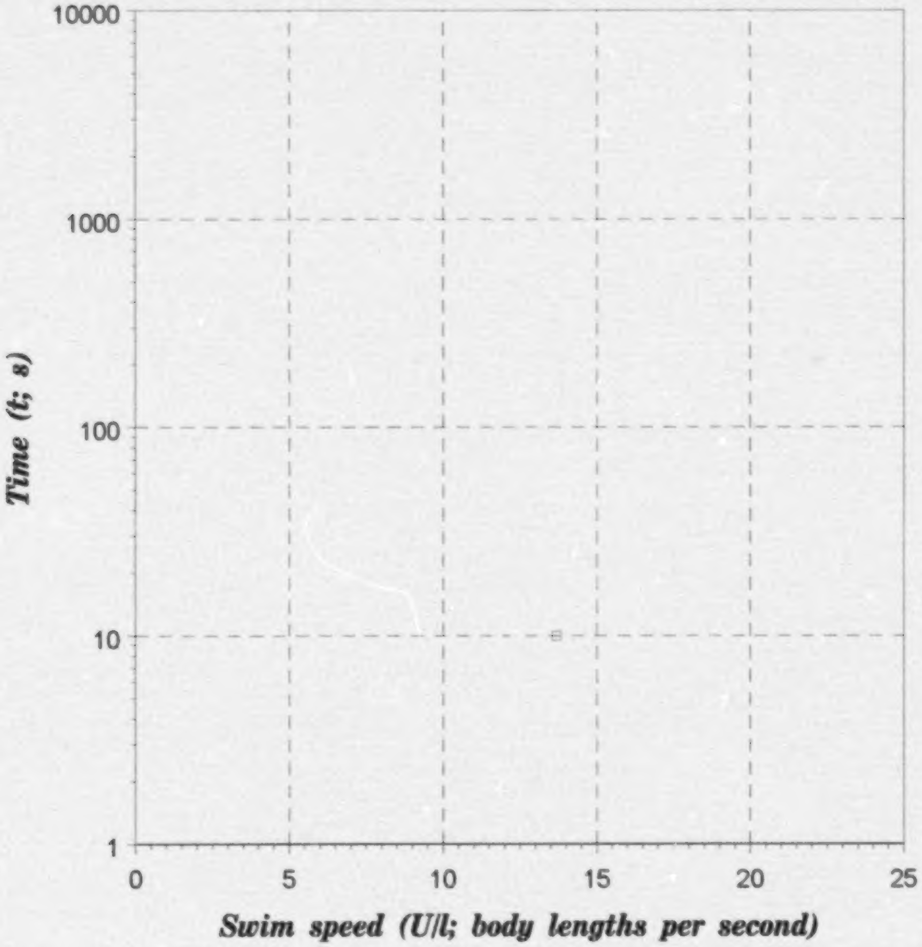


Figure A-078. Preprocessed data for Notropis buccula *(Smalleye Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-078. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	32.9	0	32.9	32.9	0	1
U (m/s)*	0.497	0	0.497	0.497	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

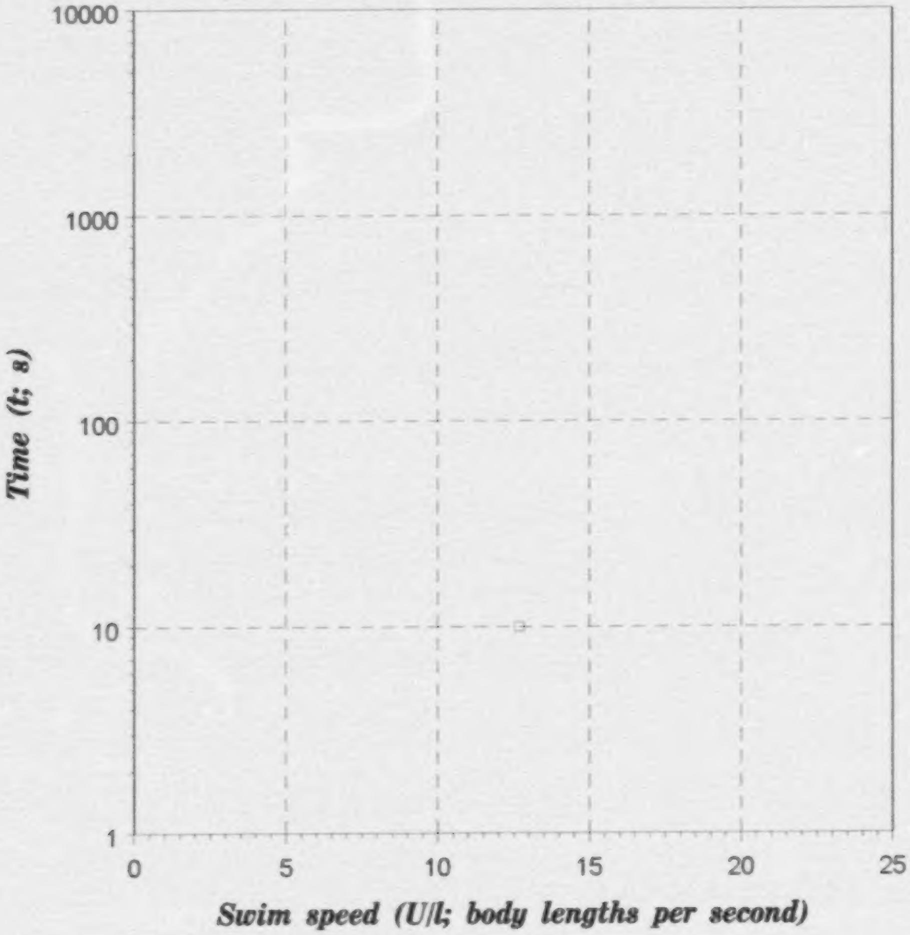


Figure A-079. Preprocessed data for Notropis buchanani *(Ghost Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner. (2009).*

Table A-079. Swim speed data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	25.9	0	25.9	25.9	0	1
U (m/s)*	0.447	0	0.447	0.447	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

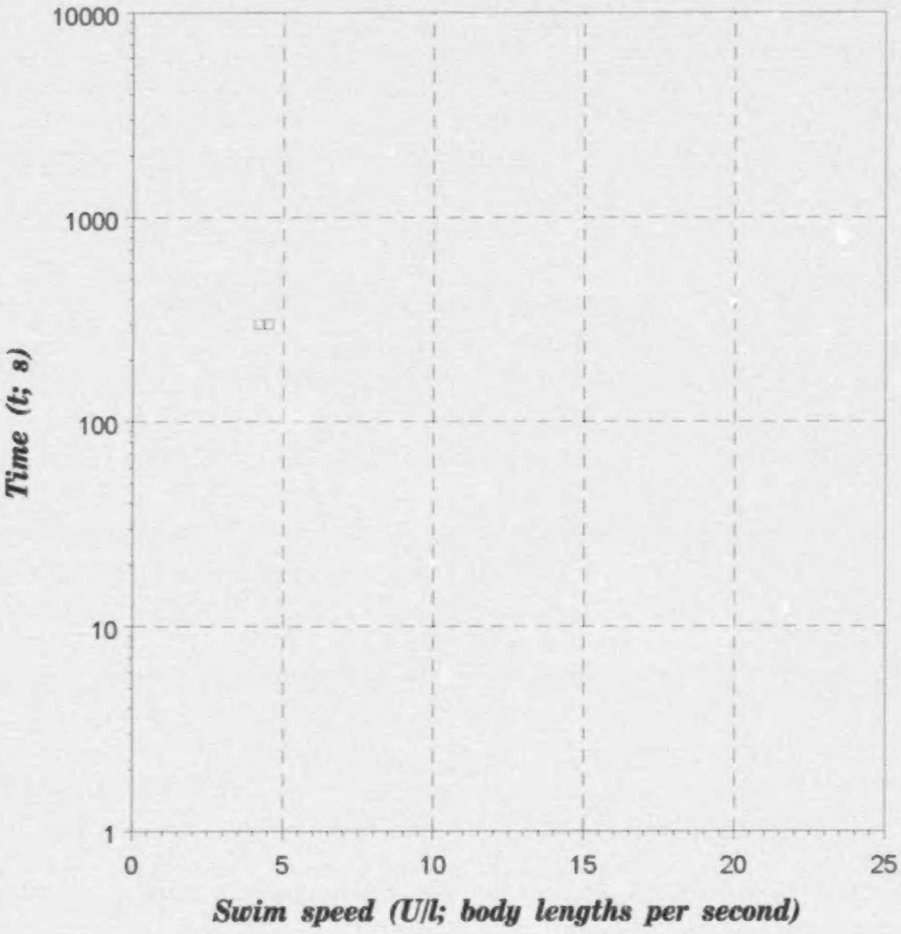


Figure A-080. Preprocessed data for Notropis hudsonius *(Spottail Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Goertzen (2011).*

Table A-080. Swim speed data summary. Fish count 32, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0.002	0.049	0.052	0.003	2
T (C)	12	0	12	12	0	1
U (m/s)*	0.22	0.001	0.219	0.221	0.002	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

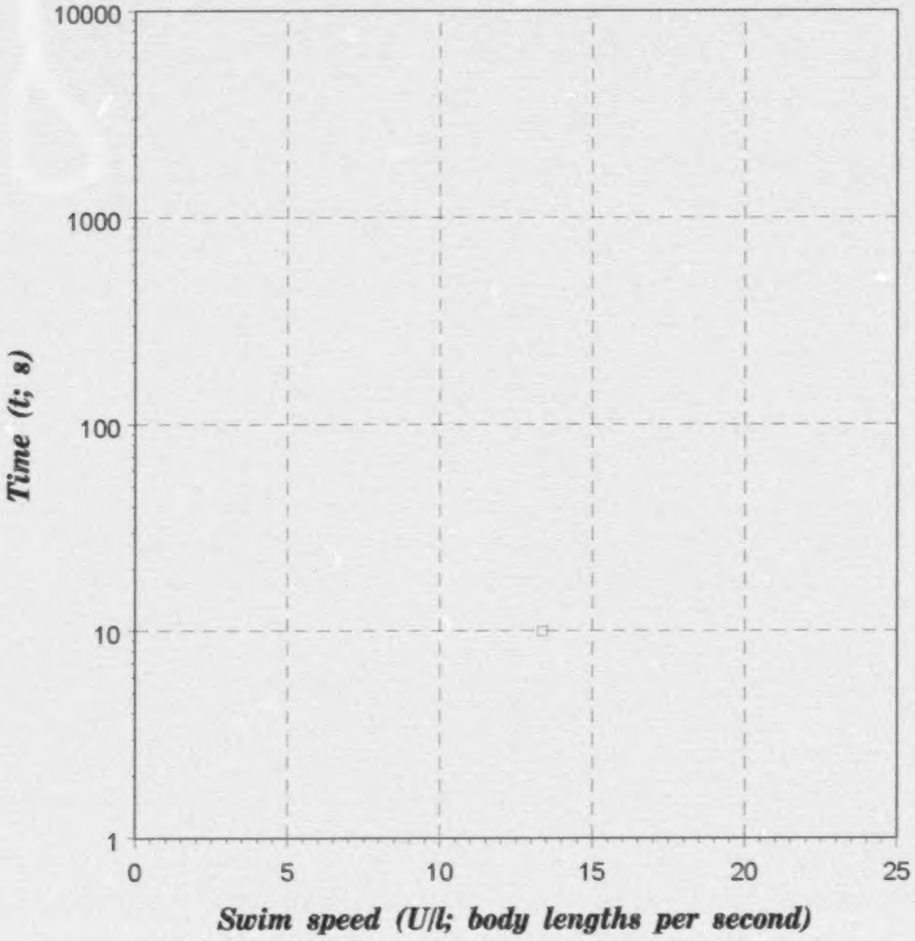


Figure A-081. Preprocessed data for Notropis oxyrhynchus *(Sharpnose Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner. (2009).*

Table A-081. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0	0.04	0.04	0	1
T (C)	32.9	0	32.9	32.9	0	1
U (m/s)*	0.534	0	0.534	0.534	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

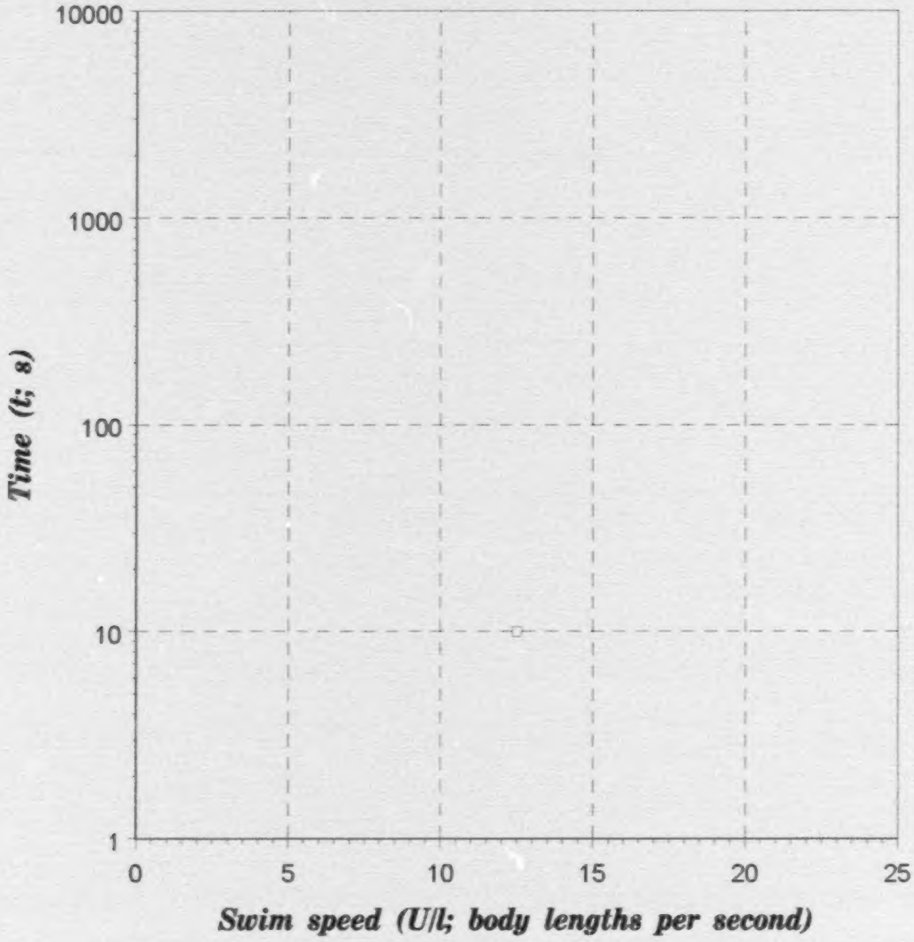


Figure A-082. Preprocessed data for Notropis sabinae *(Sabine Shiner): swim speed versus time-to-fatigue, where time (t) $\leq$150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-082. Swim speed data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.038	0	0.038	0.038	0	1
T (C)	27.4	0	27.4	27.4	0	1
U (m/s)*	0.469	0	0.469	0.469	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

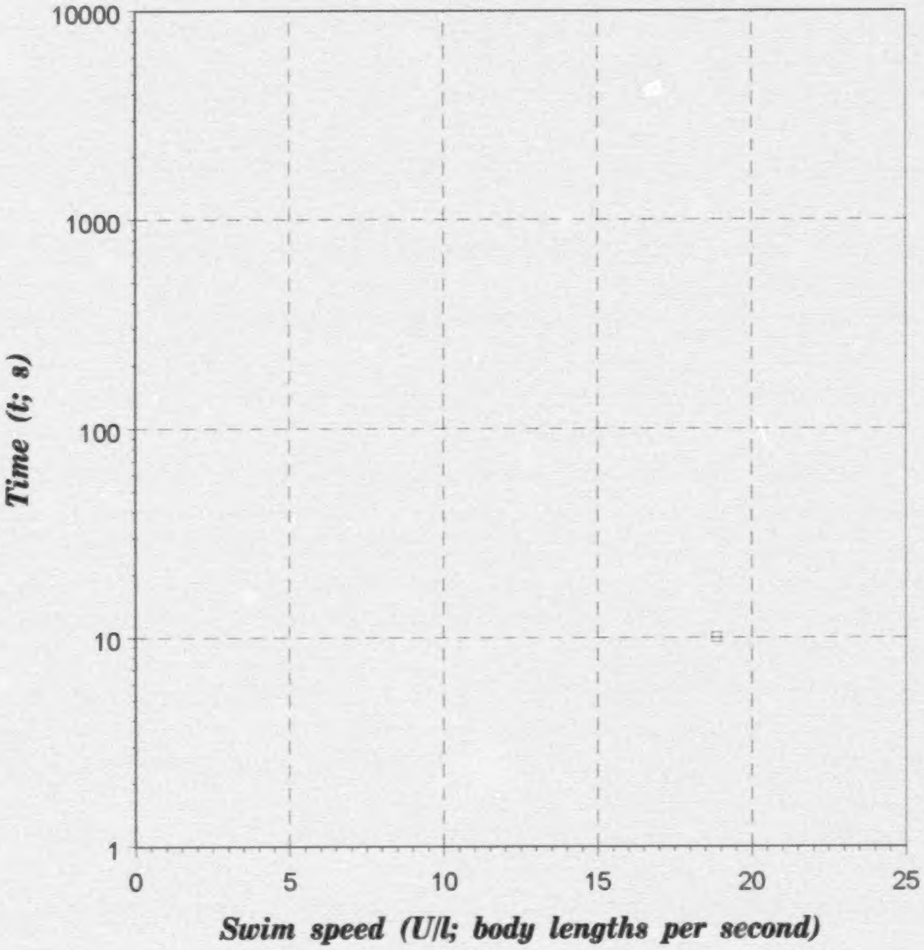


Figure A-083. Preprocessed data for Notropis shumardi *(Silverband Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-083. Swim speed data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.042	0	1
T (C)	30.5	0	30.5	30.5	0	1
U (m/s)*	0.794	0	0.794	0.794	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

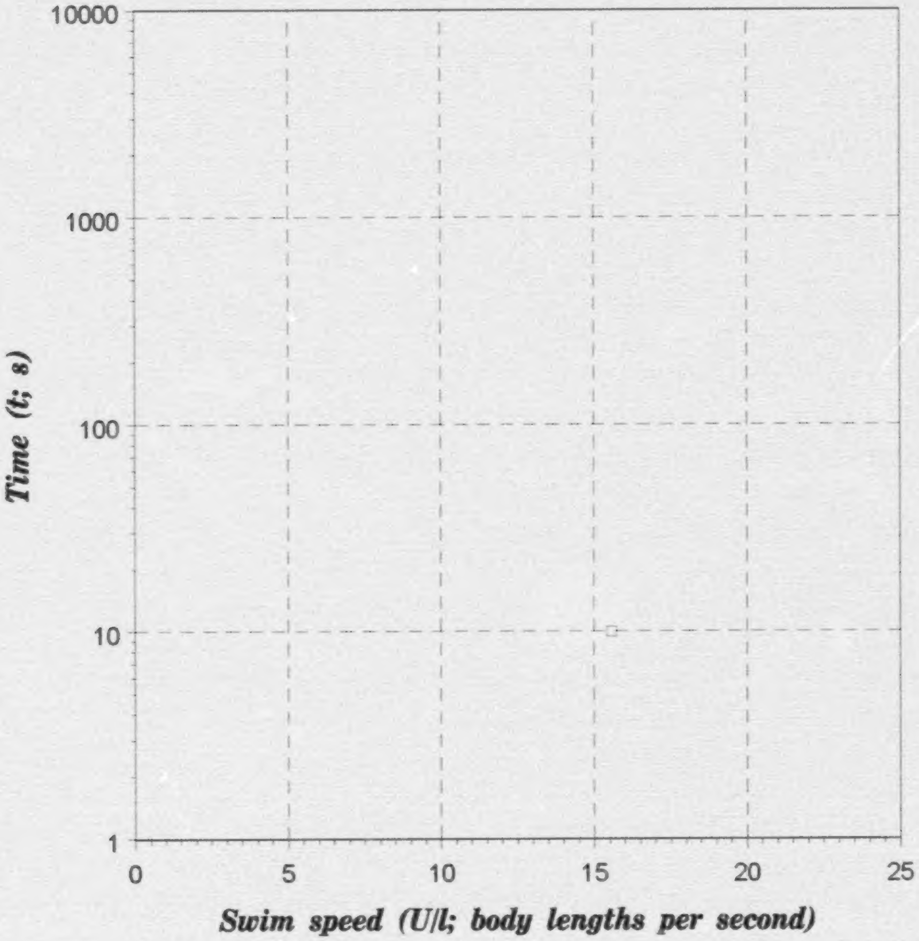


Figure A-084. Preprocessed data for Notropis stramineus *(Sand Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-084. Swim speed data summary. Fish count 18, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	28.4	0	28.4	28.4	0	1
U (m/s)*	0.665	0	0.665	0.665	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

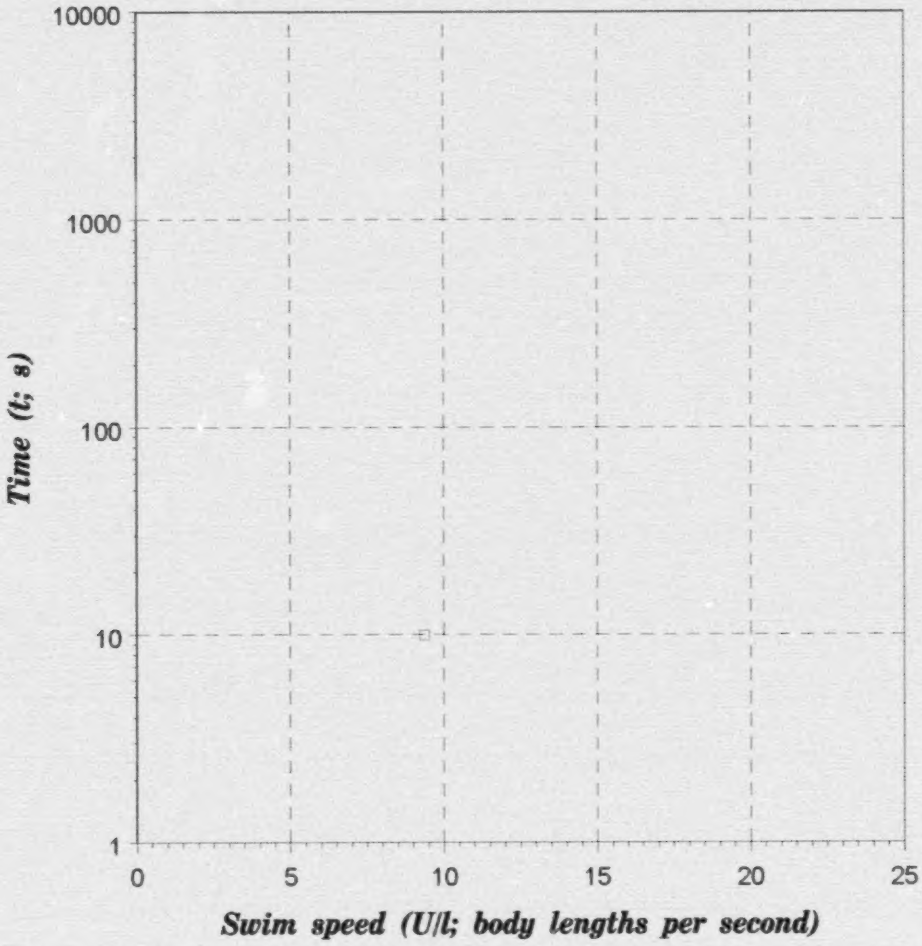


Figure A-085. Preprocessed data for Notropis texanus *(Weed Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-085. Swim speed data summary. Fish count 7, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.041	0	0.041	0.041	0	1
T (C)	27.3	0	27.3	27.3	0	1
U (m/s)*	0.387	0	0.387	0.387	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

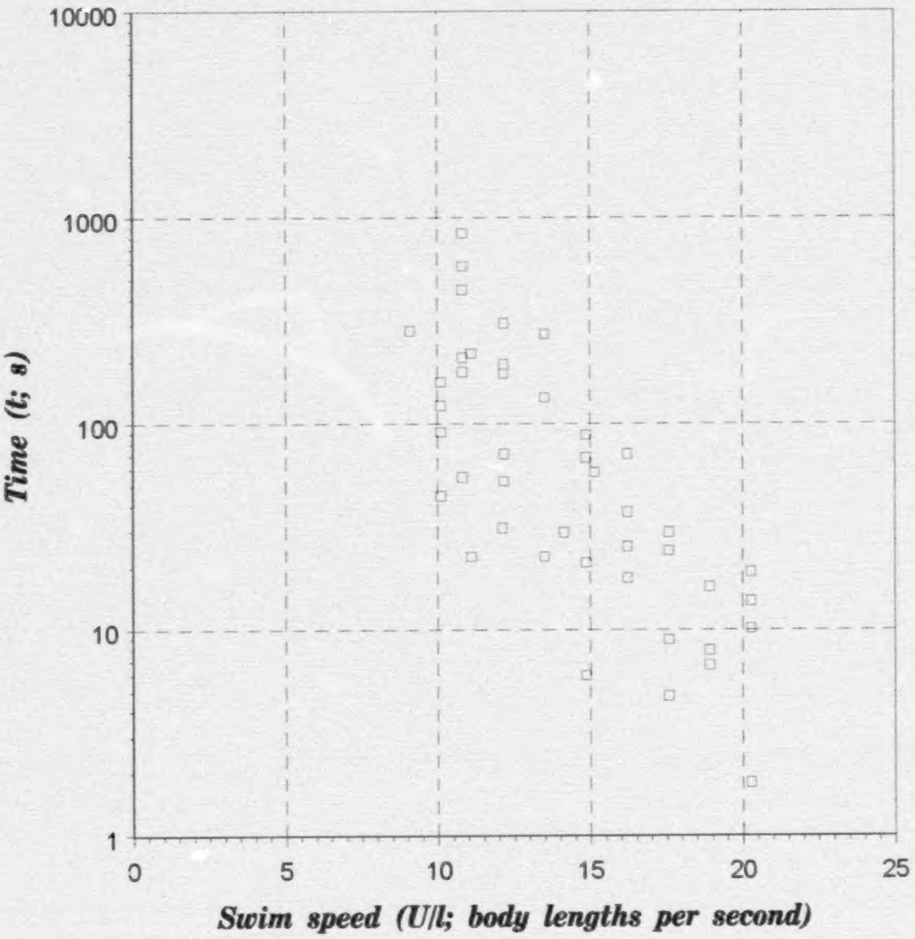


Figure A-086. Preprocessed data for Notropis topeka *(Topeka Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Adams et al. (2000).*

Table A-086. Swim speed data summary. Fish count 43, record count 43.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0.005	0.037	0.05	0.013	2
T (C)	20	0	20	20	0	1
U (m/s)*	0.559	0.115	0.4	0.75	0.35	8
t_e (s)	118	169	2	840	838	42
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

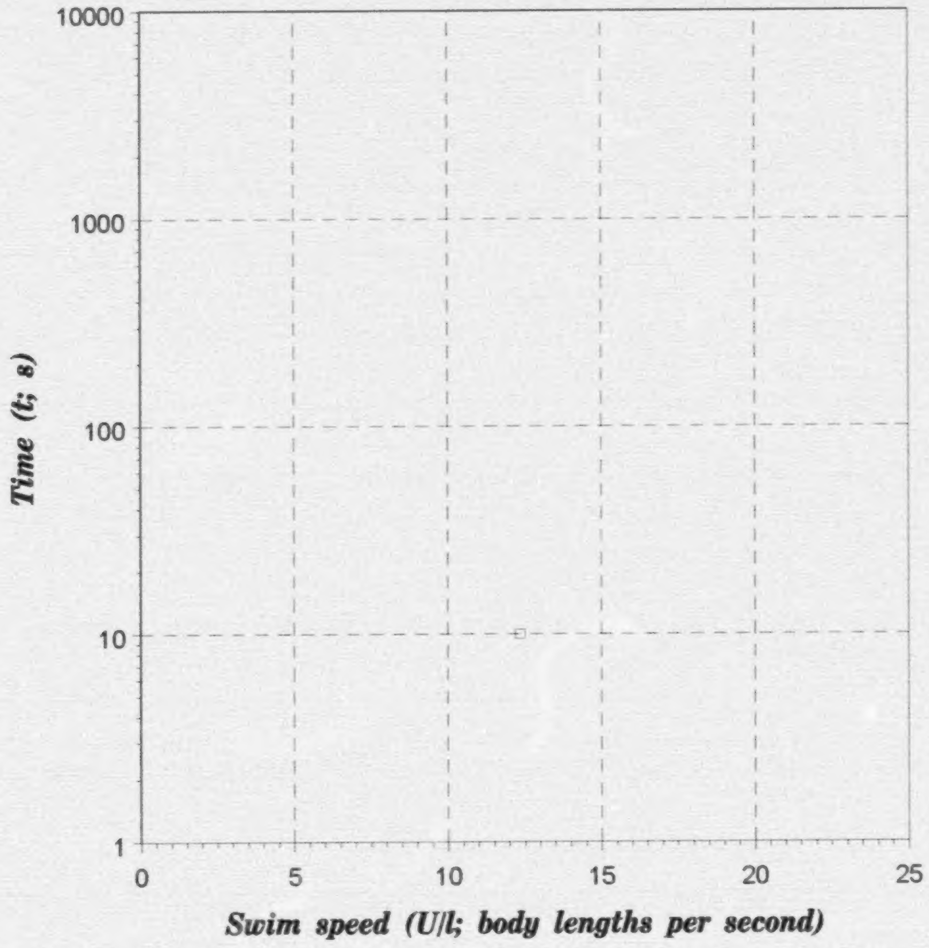


Figure A-087. Preprocessed data for Notropis volucellus *(Mimic Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-087. Swim speed data summary. Fish count 15, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	27.8	0	27.8	27.8	0	1
U (m/s)*	0.436	0	0.436	0.436	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

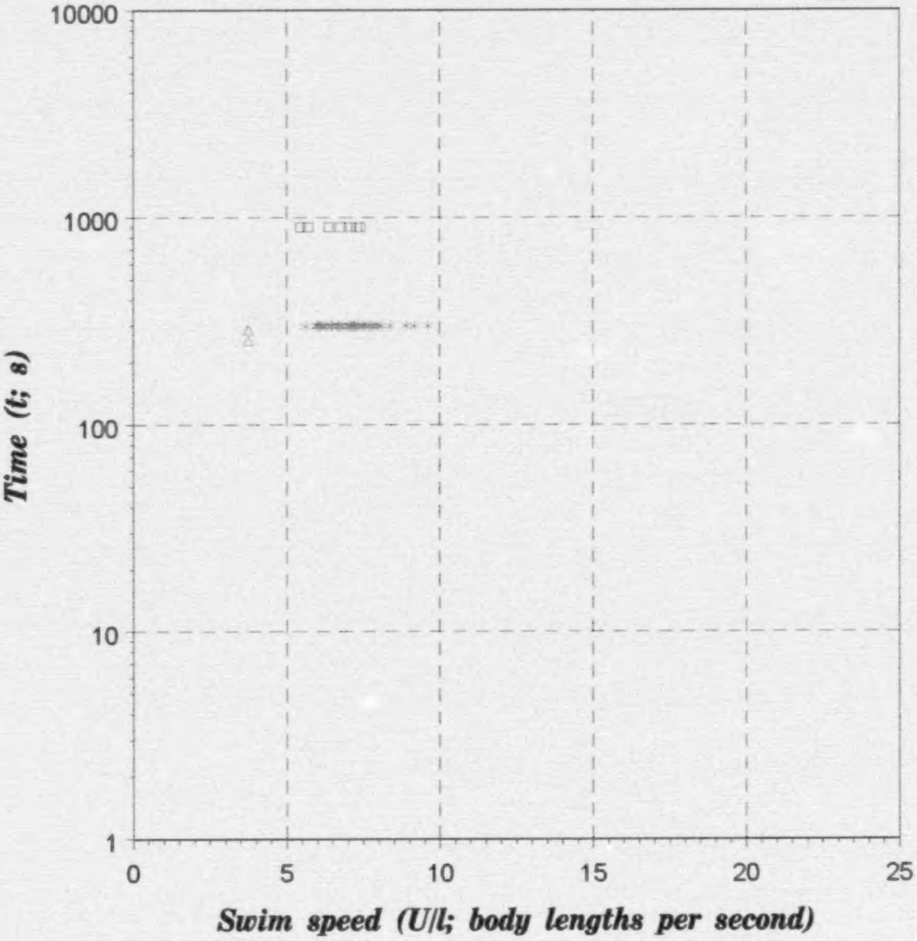


Figure A-088. Preprocessed data for Oncorhynchus clarki *(Cutthroat Trout): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Hawkins and Quinn (1996); red triangles are data from Zale et al. (2005); green stars are data from Aedo et al. (2009).*

Table A-088. Swim speed data summary. Fish count 161, record count 49.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.099	0.055	0.038	0.24	0.202	27
T (C)	17.8	2	13	19	6	3
U (m/s)*	0.584	0.156	0.247	0.9	0.653	43
t_e (s)	272	17	255	288	33	2
$t_{\Delta t}$ (s)**	734	269	300	900	600	2

* U=critical velocity (U_{crit})
** t=time step (Δt)

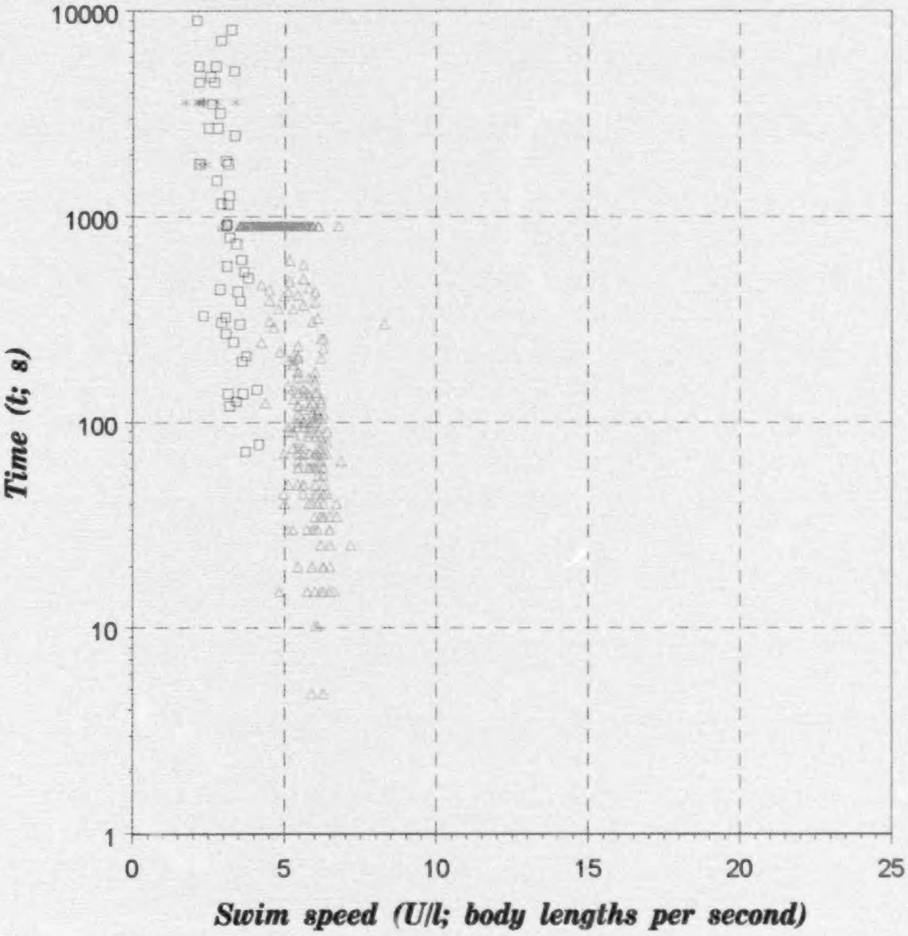


Figure A-089. Preprocessed data for Oncorhynchus gorbuscha *(Pink Salmon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Brett (1982); red triangles are data from Smith and Carpenter (1987); green stars are data from Williams and Brett (1987).*

Table A-089. Swim speed data summary. Fish count 1097, record count 445.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.325	0.217	0.021	0.607	0.586	55
T (C)	11.8	4.2	4	20	16	7
U (m/s)*	0.806	0.498	0.097	2.38	2.283	143
t_e (s)	541	1167	5	9000	8995	99
$t_{\Delta t}$ (s)**	2679	1135	900	3600	2700	3

* U=critical velocity (U_{crit})
** t=time step (Δt)

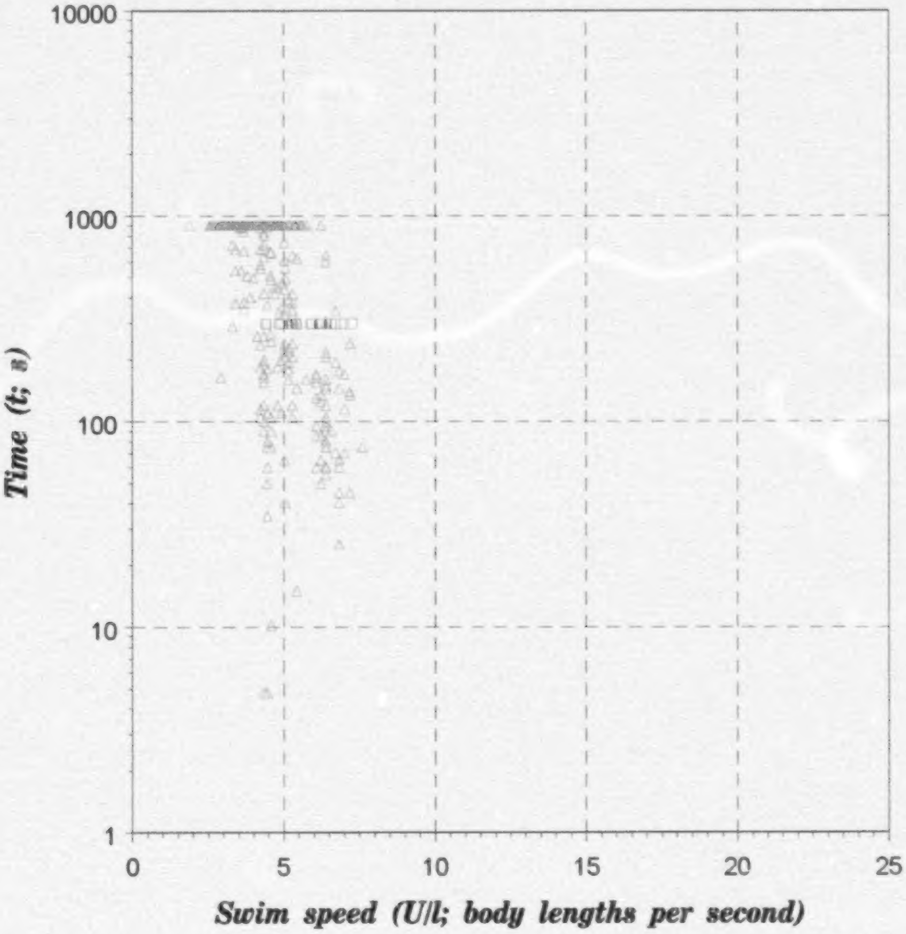


Figure A-090. Preprocessed data for Oncorhynchus keta *(Chum Salmon): swim speed versus time-to-fatigue, where time (t) $\leq$150 minutes. Blue squares are data from Houston (1959); red triangles are data from Smith and Carpenter (1987).*

Table A-090. Swim speed data summary. Fish count 445, record count 445.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.039	0.004	0.035	0.093	0.058	15
T (C)	7.1	2.5	4	10	6	3
U (m/s)*	0.177	0.043	0.098	0.342	0.244	163
t_e (s)	462	345	5	900	895	99
$t_{\Delta t}$ (s)**	851	165	300	900	600	2

* U=critical velocity (U_{crit})

** t=time step (Δt)

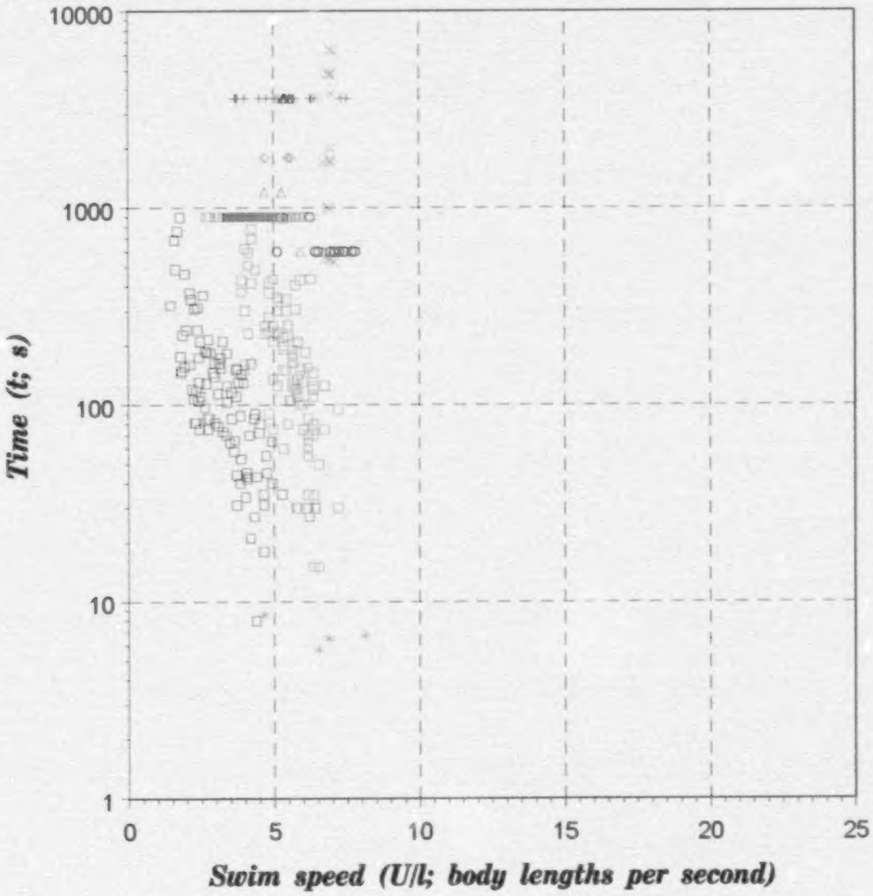


Figure A-091. Preprocessed data for Oncorhynchus kisutch *(Coho Salmon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Paulik and DeLacy (1957); red triangles are data from David et al. (1963); green stars are data from Weaver (1963); black circles are data from Dahlberg et al. (1968); turquoise diamonds are data from Howard (1975); blue crosses are data from Glova and Mcinerney (1977); red x's are data from Taylor and McPhail (1985); black squares are data from Smith and Carpenter (1987); black triangles are data from Brauner et al. (1992); turquoise stars are data from MacKinnon and Farrell (1992); blue circles are data from Nikl and Farrell (1993); red diamonds are data from Brauner et al. (1994b).*

Table A-091. Swim speed data summary. Fish count 1184, record count 408.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.143	0.181	0.03	0.75	0.72	54
T (C)	11.8	4.4	3	23	20	19
U (m/s)*	0.71	0.849	0.097	4.059	3.962	172
t_e (s)	1104	1712	6	6354	6348	145
$t_{\Delta t}$ (s)**	2583	1311	600	3600	3000	5

* U=critical velocity (U_{crit})
** t=time step (Δt)

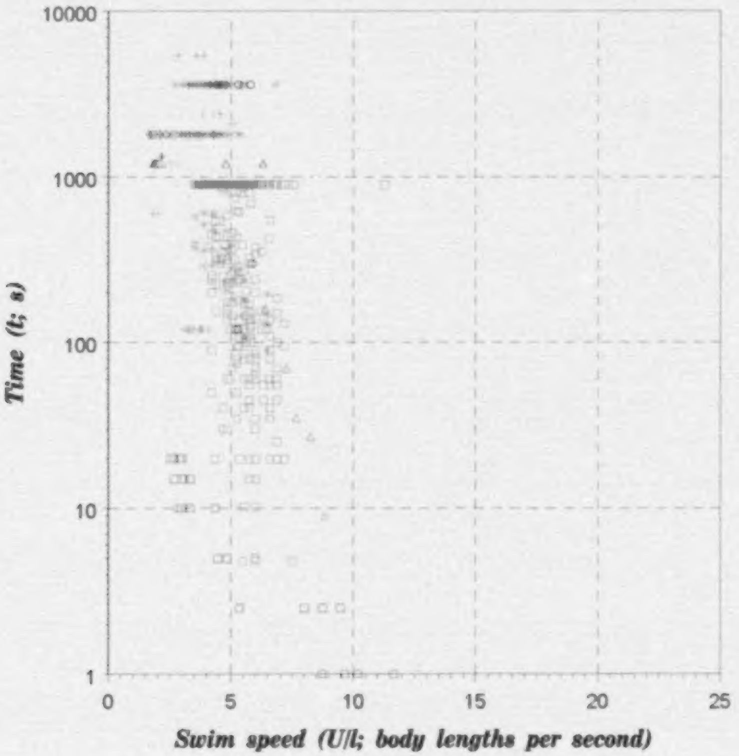


Figure A-092. Preprocessed data for Oncorhynchus mykiss *(Rainbow Trout): swim speed versus time-to-fatigue, where time (t)* ≤ 150 *minutes. Blue squares are data from Bainbridge (1960); red triangles are data from Tsukamoto (1975); green stars are data from Beamish (1980); black circles are data form Graham and Wood (1981); turquoise diamonds are data from Daxboeck (1982); blue crosses area data from Mellas and Haynes (1985); red x's are data from Duthie and Hughes (1987); green squares are data from Smith and Carpenter (1987); black triangles are data from Farrell et al. (1990); turquoise stars are data from Ferrell et al. (1991); blue circles are data from Gamperl et al. (1991); red diamonds are data from Pearson and Stevens (1991); dark green crosses data are from Gallaugher et al. (1992); black x's are data from Wilson and Wood (1992); turquoise squares are data from Nikl and Farrell (1993); blue triangles are data from Johansen et al. (1994); red stars are data from Mitton and McDonald (1994); black crosses are data from Wilson et al. (1994); red crosses are data from Aslop and Wood (1997); green crosses are data from Anderson et al. (1997); blue crosses are data from Jain et al. (1997); turquoise crosses are data from Peake et al. (1997a); fuchsia crosses are data from McDonald et al.(1998); yellow crosses are data from Gregory and Wood (1999); grey crosses are data from Jones and Moffitt (2004).*

Table A-092. Swim speed data summary. Fish count 1534, record count 802.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.116	0.106	0.022	0.42	0.398	101
T (C)	11.8	3.5	6	18.5	12.5	20
U (m/s)*	0.436	0.322	0 092	2.71	2.618	336
t_e (s)	658	689	1	3600	3599	131
$t_{\Delta t}$ (s)**	1353	1250	120	5400	5280	9

* U=critical velocity (U_{crit})

** t=time step (Δt)

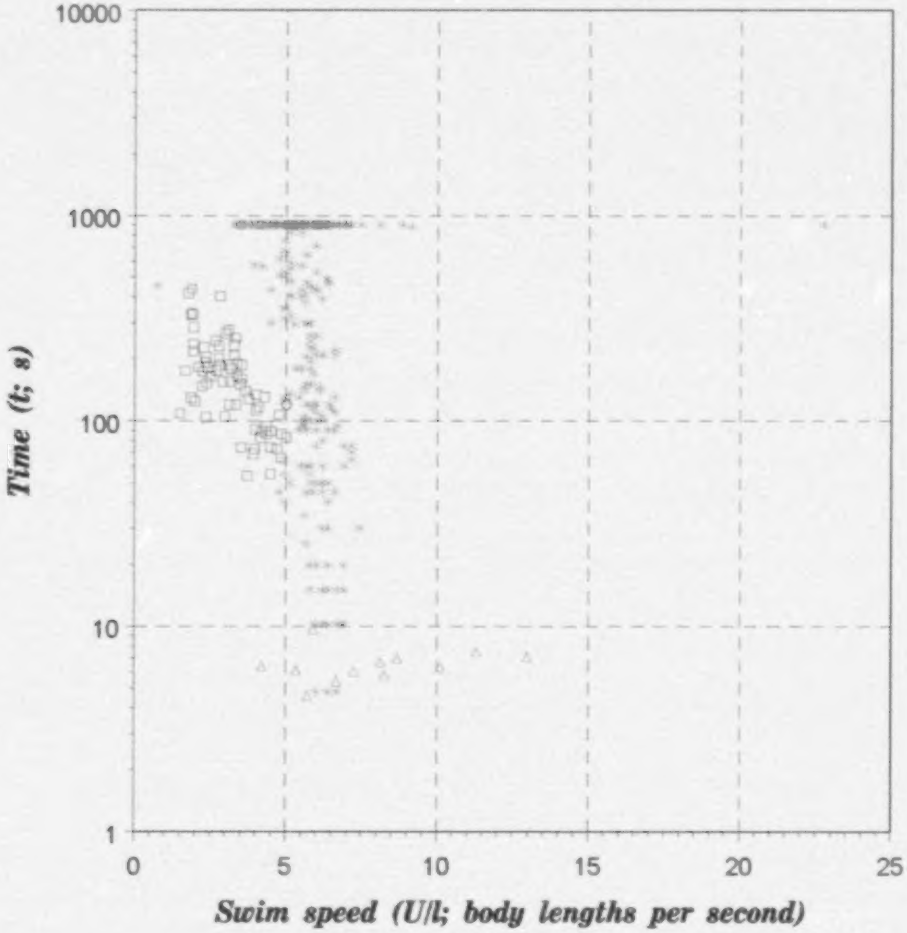


Figure A-093. Preprocessed data for Oncorhynchus mykiss *(Steelhead Trout): swim speed versus time-to-fatigue, where time (t) ≤ 150 minutes. Blue squares are data from Paulik and DeLacy (1957); red triangles are data from Weaver (1963); green stars are data from Smith and Carpenter (1987); black circles are data from Webb (1993); turquoise diamonds are data from Hawkins and Quinn (1996).*

Table A-093. Swim speed data summary. Fish count 1867, record count 574.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.45	0.271	0.021	0.82	0.799	27
T (C)	16.4	4.1	7	19	12	6
U (m/s)*	2.751	1.772	0.092	6.406	6.314	204
t_e (s)	93	238	5	900	895	143
$t_{\Delta t}$ (s)**	872	147	120	900	780	2

* U=critical velocity (U_{crit})

** t=time step (Δt)

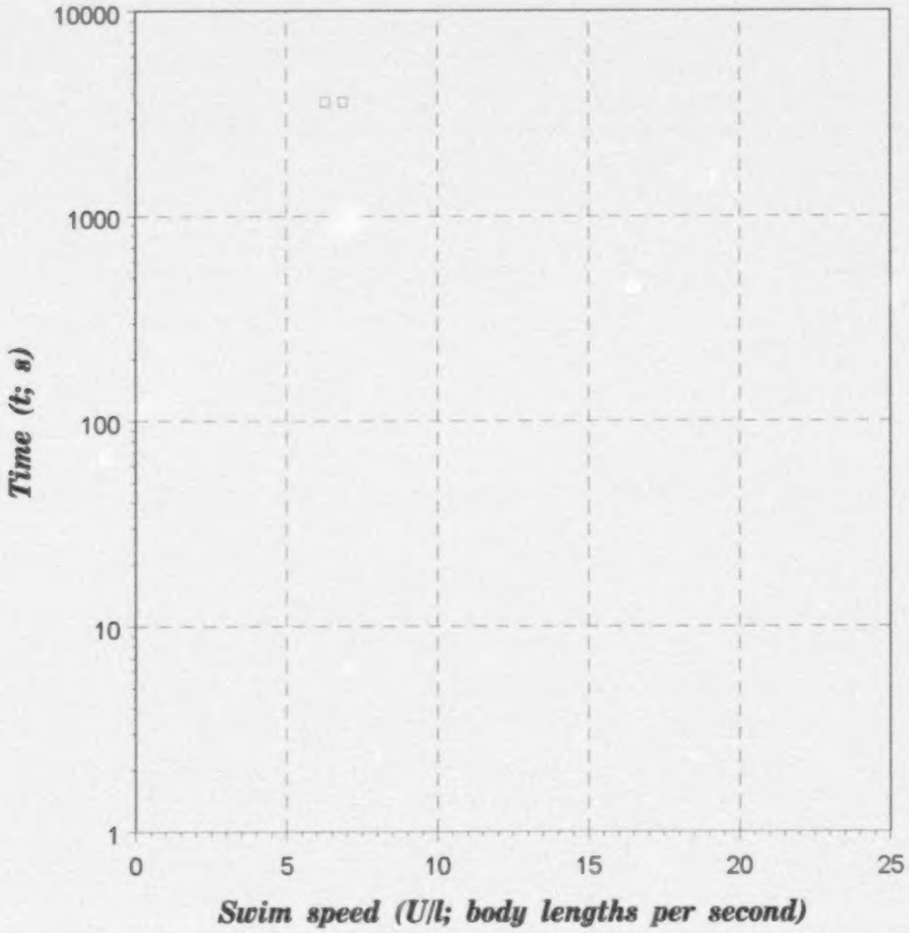


Figure A-094. Preprocessed data for Oncorhynchus nerka *(Kokanee Salmon): swim speed versus time-to-fatigue, where time (t)* ≤ 150 *minutes. Blue squares are data from Taylor and Foote (1991).*

Table A-094. Swim speed data summary. Fish count 100, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.085	0.007	0.078	0.092	0.014	2
T (C)	10	0	10	10	0	1
U (m/s)*	0.556	0.023	0.533	0.578	0.045	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	3600	0	3600	3600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

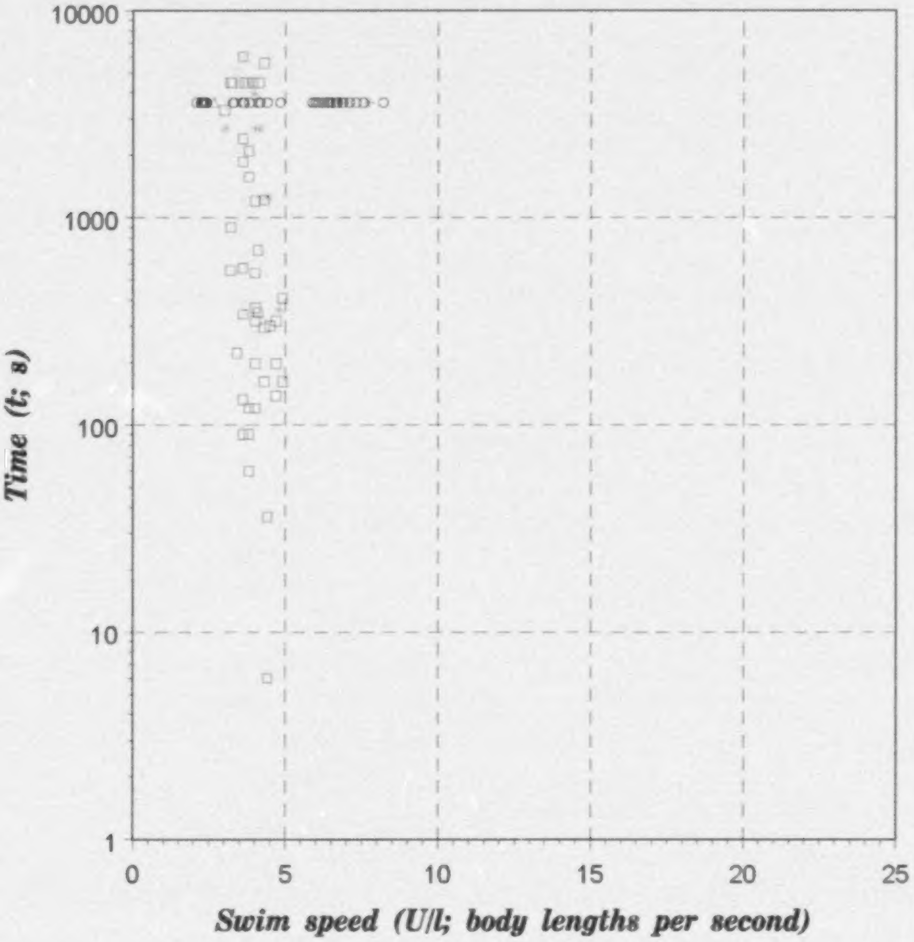


Figure A-095. Preprocessed data for Oncorhynchus nerka *(Sockeye Salmon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Brett (1964); red triangles are data from Brett (1965); green stars are data from Brett (1967); black circles are data from Brett and Glass (1973); turquoise diamonds are data from Brett (1982); blue crosses are data from Taylor and Foote (1991).*

Table A-095. Swim speed data summary. Fish count 361, record count 118.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.191	0.156	0.055	0.621	0.566	66
T (C)	13.2	4	5	24	19	6
U (m/s)*	0.784	0.43	0.371	2.37	1.999	67
t_e (s)	2022	1987	6	9000	8994	60
$t_{\Delta t}$ (s)**	3698	431	2700	4500	1800	3

* U=critical velocity (U_{crit})
** t=time step (Δt)

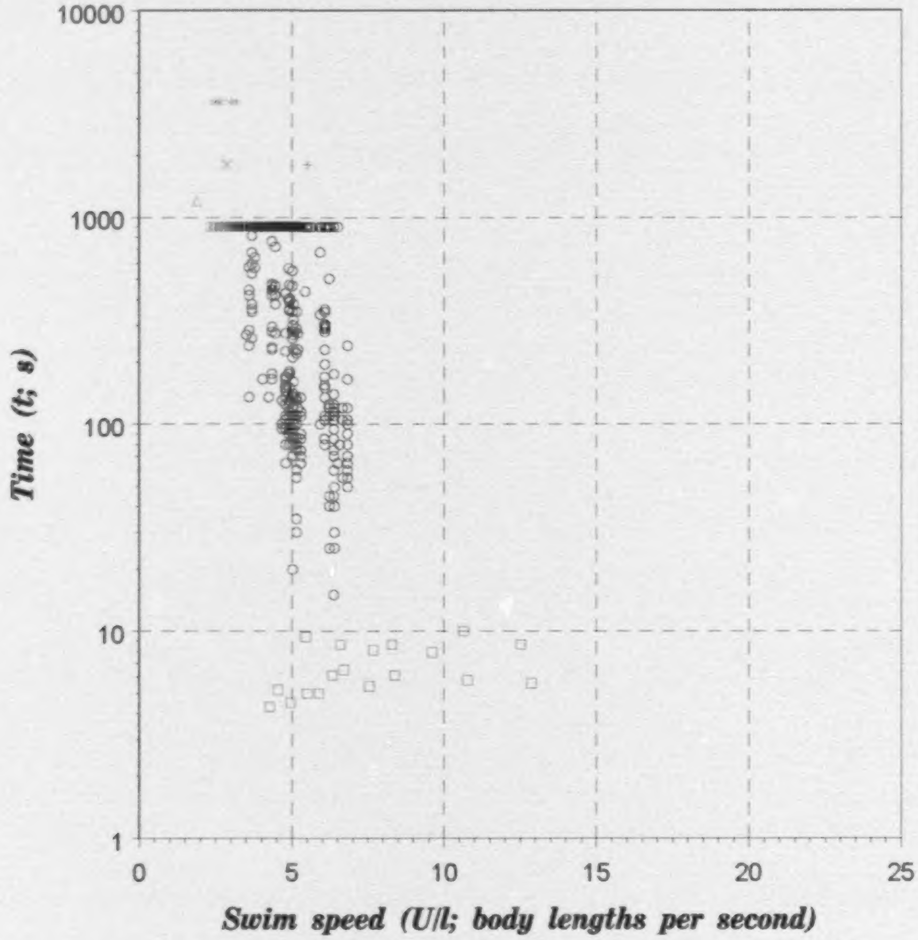


Figure A-096. Preprocessed data for Oncorhynchus tshawytscha *(Chinook Salmon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Weaver (1963); red triangles are data from Farrell and Steffensen (1987); green stars are data from Randall et al. (1987); black circles are data from Smith and Carpenter (1987); turquoise diamonds are data from Brauner et al. (1993); blue crosses are data from Nikl and Farrell (1993); red x's are data from Thorarensen (1993); black squares are data from Muir et al. (1994); black triangles are data from Adams et al. (1998).*

Table A-096. Swim speed data summary. Fish count 1250, record count 492.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.323	0.299	0.036	0.927	0.891	24
T (C)	12.8	5.9	3	19	16	26
U (m/s)*	2.009	1.982	0.115	6.223	6.109	226
t_e (s)	98	213	4	900	896	94
$t_{\Delta t}$ (s)**	1169	735	900	3600	2700	4

* U=critical velocity (U_{crit})
** t=time step (Δt)

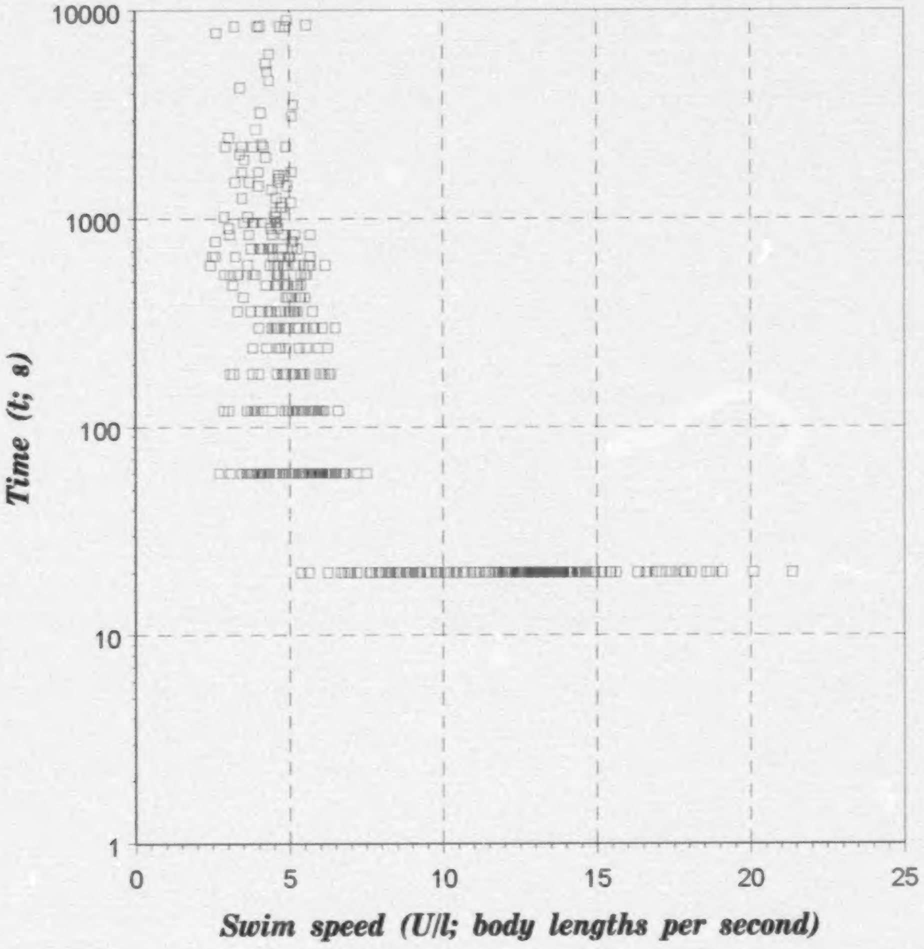


Figure A-097. Preprocessed data for Osmerus eperlanus *(European Smelt): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Clough et al. (2003).*

Table A-097. Swim speed data summary. Fish count 484, record count 484.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.097	0.023	0.048	0.165	0.117	91
T (C)	11.8	3.4	5.4	18	12.6	25
U (m/s)*	0.7	0.341	0.316	1.455	1.139	95
t_e (s)	795	1515	60	9000	8940	48
$t_{\Delta t}$ (s)**	20	0	20	20	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

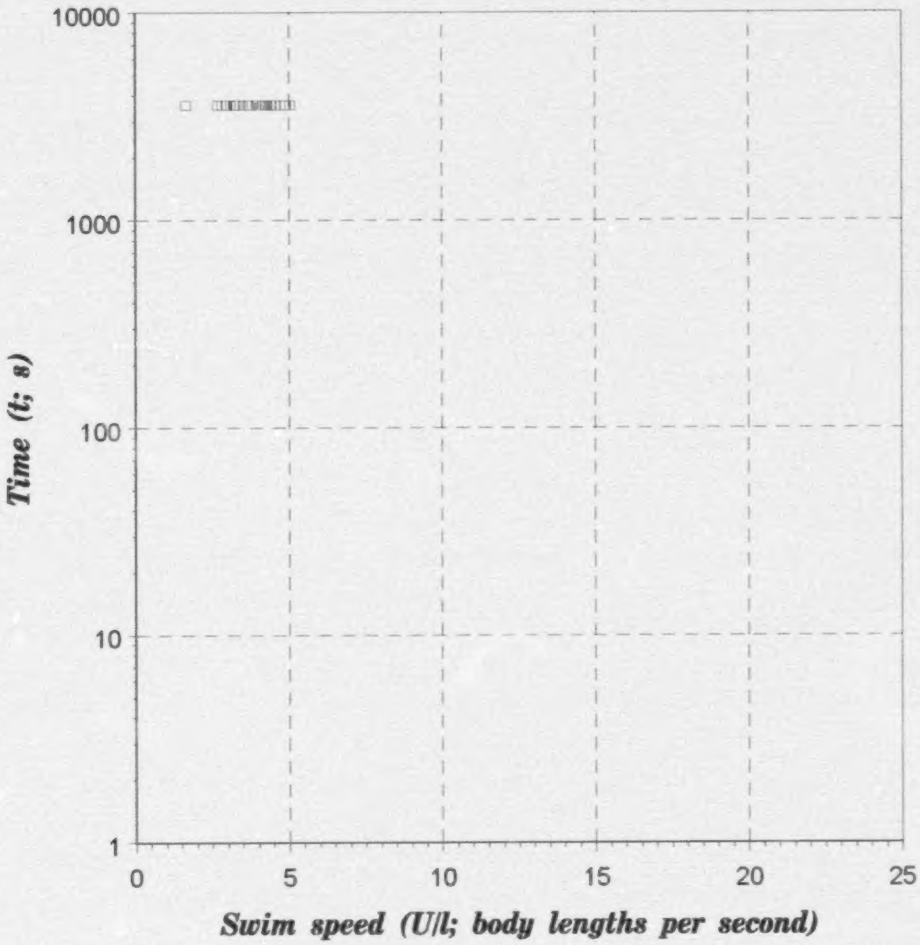


Figure A-098. Preprocessed data for Osmerus mordax *(Rainbow smelt): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Griffiths (1979).*

Table A-098. Swim speed data summary. Fish count 31, record count 31.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.099	0.034	0.07	0.163	0.093	20
T (C)	10	0	10	10	0	1
U (m/s)*	0.359	0.084	0.203	0.507	0.304	25
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	3600	0	3600	3600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

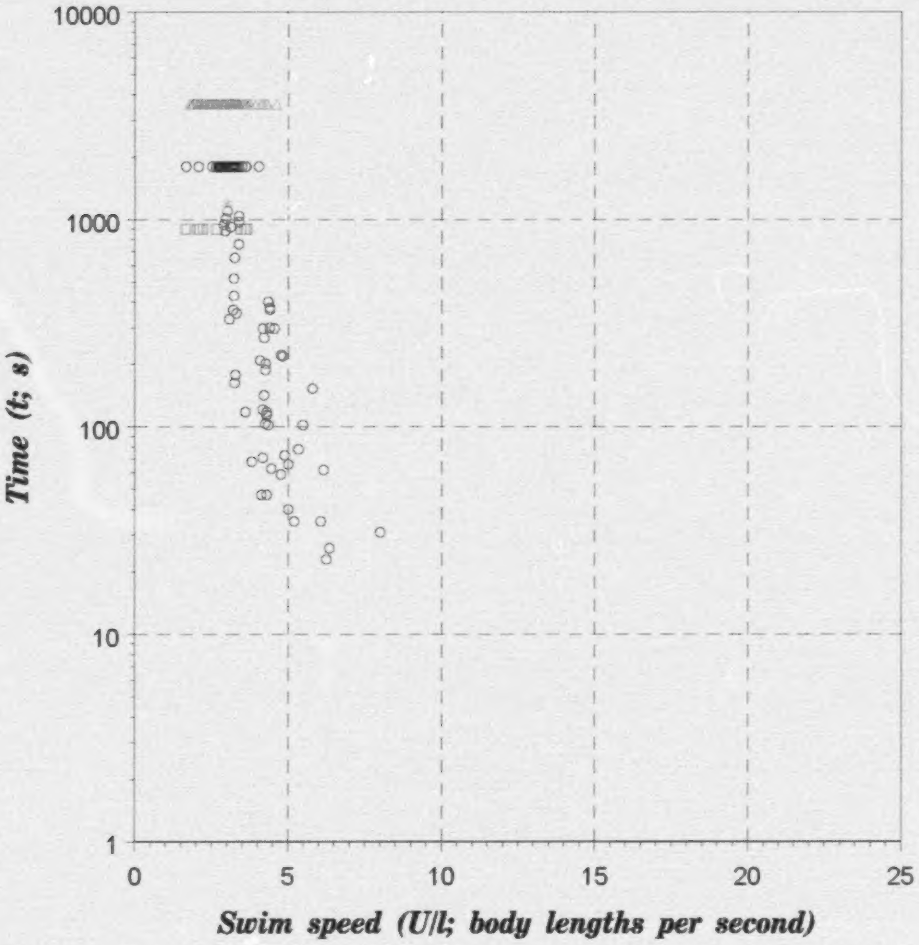


Figure A-099. Preprocessed data for Perca flavescens *(Yellow Perch): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Otto and O'Hare-Rice (1974); red triangles are data from Griffiths (1979); green stars are data from McDonald et al. (1991); black circles are data from Taylor et al. (2004).*

Table A-099. Swim speed data summary. Fish count 245, record count 208.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.128	0.039	0.05	0.241	0.191	112
T (C)	17.2	4.9	10	21	11	4
U (m/s)*	0.385	0.084	0.14	0.537	0.397	113
t_e (s)	299	313	23	1100	1077	48
$t_{\Delta t}$ (s)**	2663	1169	900	3600	2700	4

* U=critical velocity (U_{crit})
** t=time step (Δt)

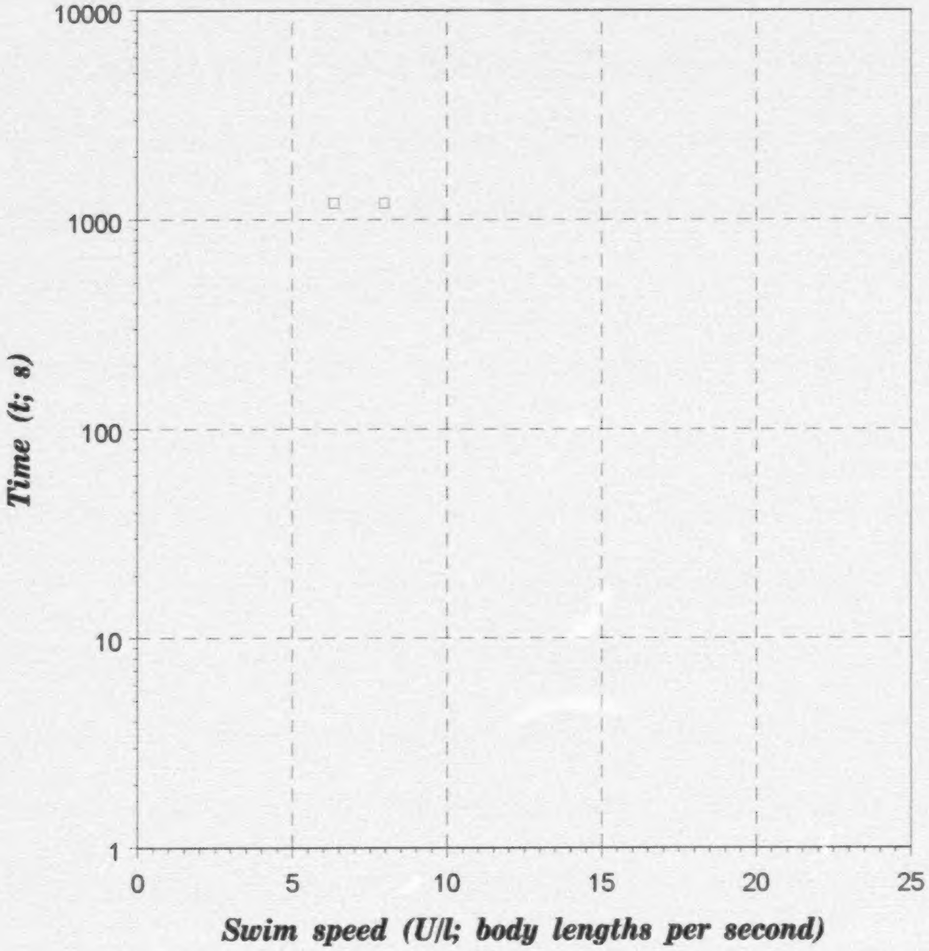


Figure A-100. Preprocessed data for Perca fluviatilis *(European Perch): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Tudorache et al. (2008).*

Table A-100. Swim speed data summary. Fish count 16, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.14	0.04	0.101	0.178	0.077	2
T (C)	15	0	15	15	0	1
U (m/s)*	0.968	0.168	0.806	1.13	0.325	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	1200	0	1200	1200	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

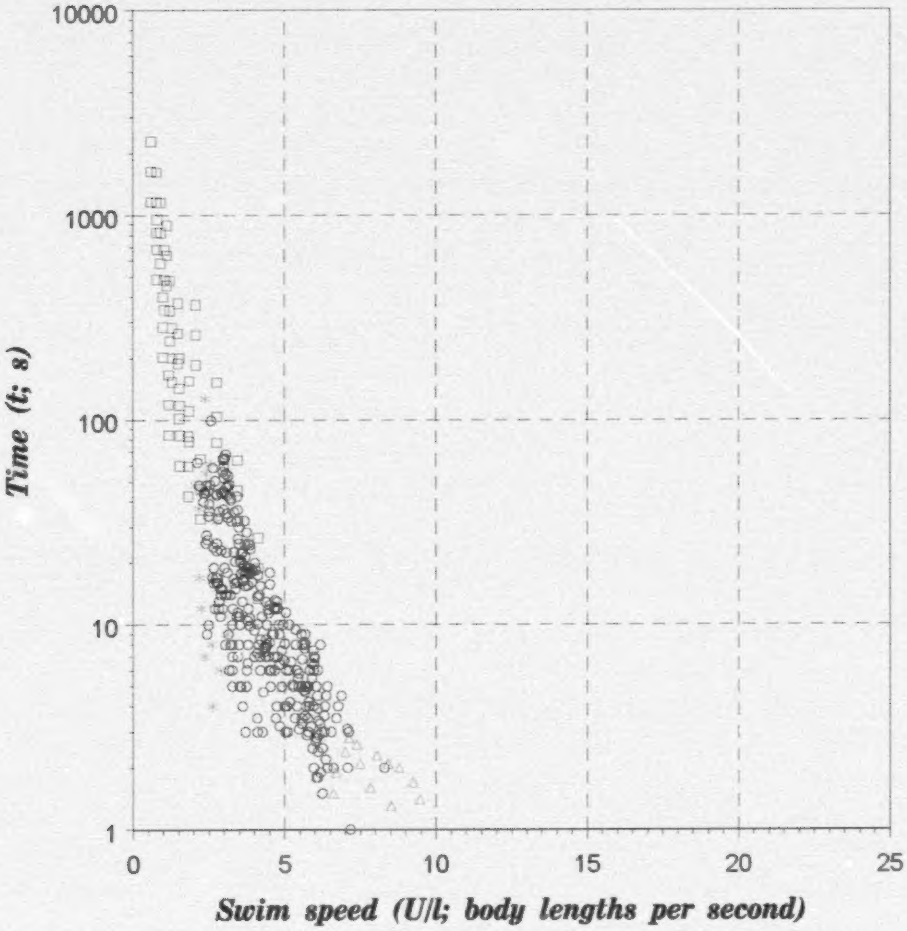


Figure A-101. Preprocessed data for Petromyzon marinus *(Sea Lamprey): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Beamish (1974); red triangles are data from Hanson (1980); green stars are data from Bergstedt et al. (1981); black circles are data from McAuley (1996).*

Table A-101. Swim speed data summary. Fish count 1010, record count 383.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.393	0.124	0.145	0.59	0.445	38
T (C)	12.4	5.1	5	23	18	40
U (m/s)*	1.255	1.107	0.3	4.091	3.791	183
t_e (s)	237	399	1	2294	2293	219
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

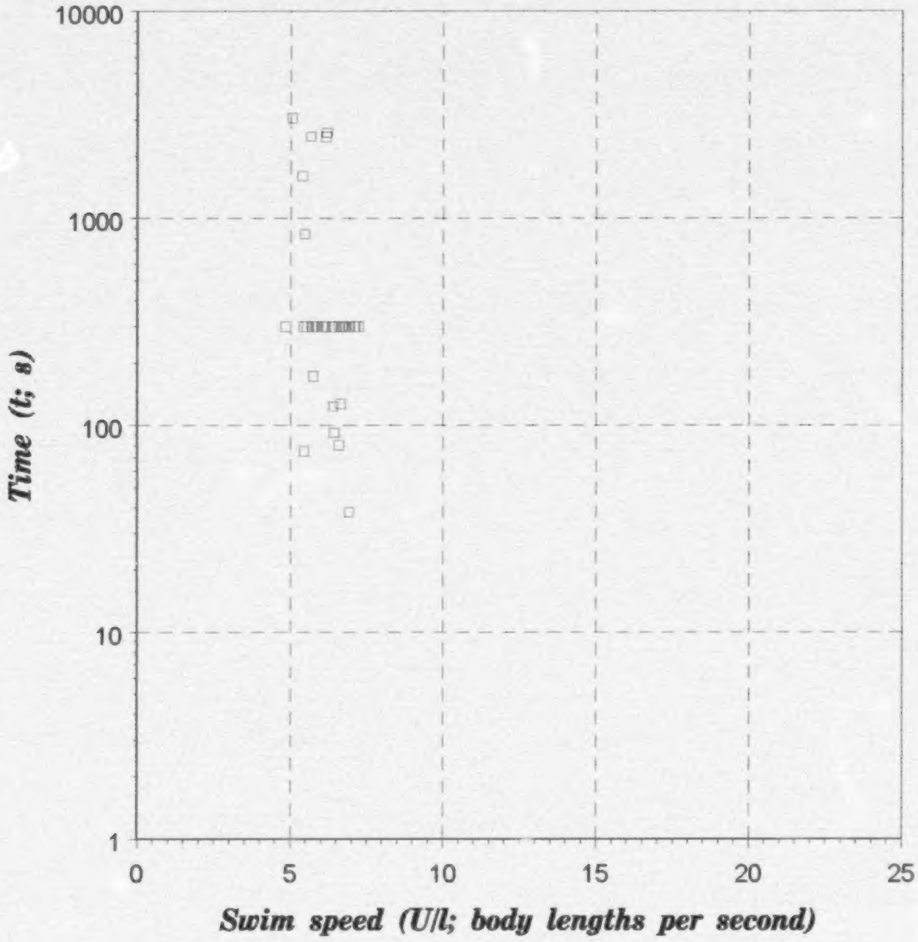


Figure A-102. Preprocessed data for Pimelodus maculatus *(Mandi): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Santos et al. (2008).*

Table A-102. Swim speed data summary. Fish count 38, record count 38.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.234	0.023	0.19	0.29	0.1	15
T (C)	26.4	0.5	25.1	28	2.9	12
U (m/s)*	1.439	0.144	1.16	1.728	0.568	35
t_e (s)	1060	1199	38	3060	3022	13
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

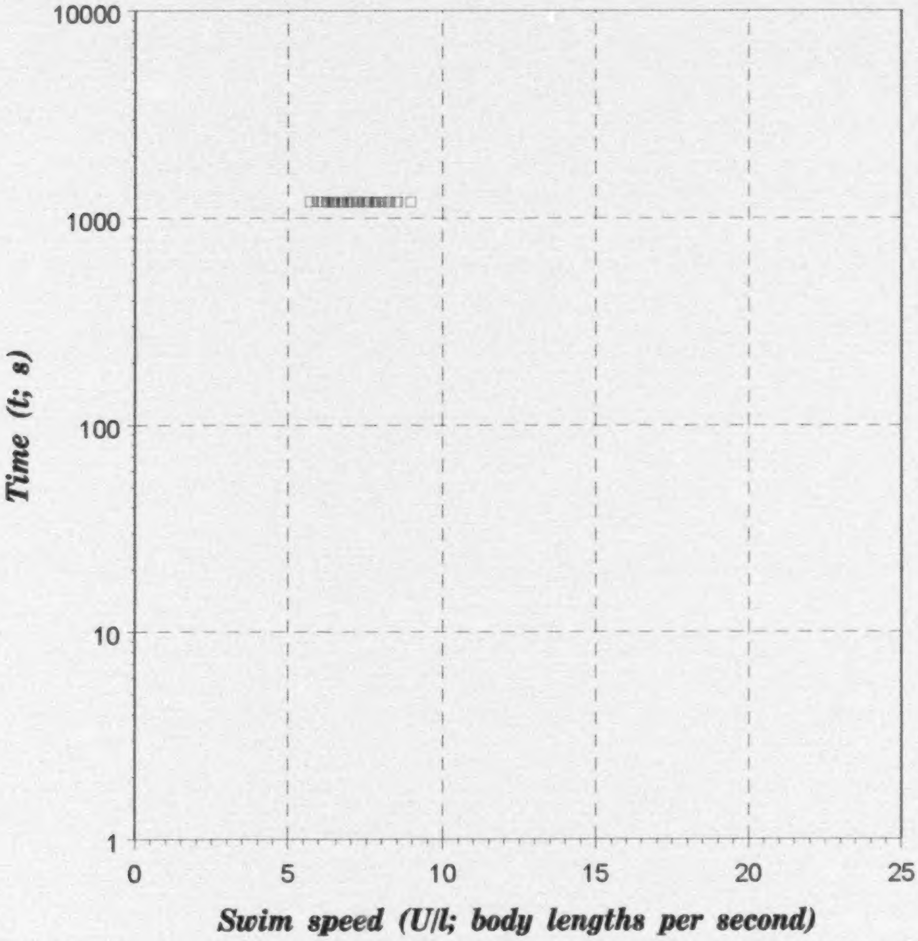


Figure A-103. Preprocessed data for Pimephales promelas *(Fathead Minnow): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Kolok (1998).*

Table A-103. Swim speed data summary. Fish count 49, record count 49.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.061	0.002	0.059	0.064	0.005	3
T (C)	24	0	24	24	0	1
U (m/s)*	0.435	0.048	0.336	0.546	0.21	42
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	1200	0	1200	1200	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

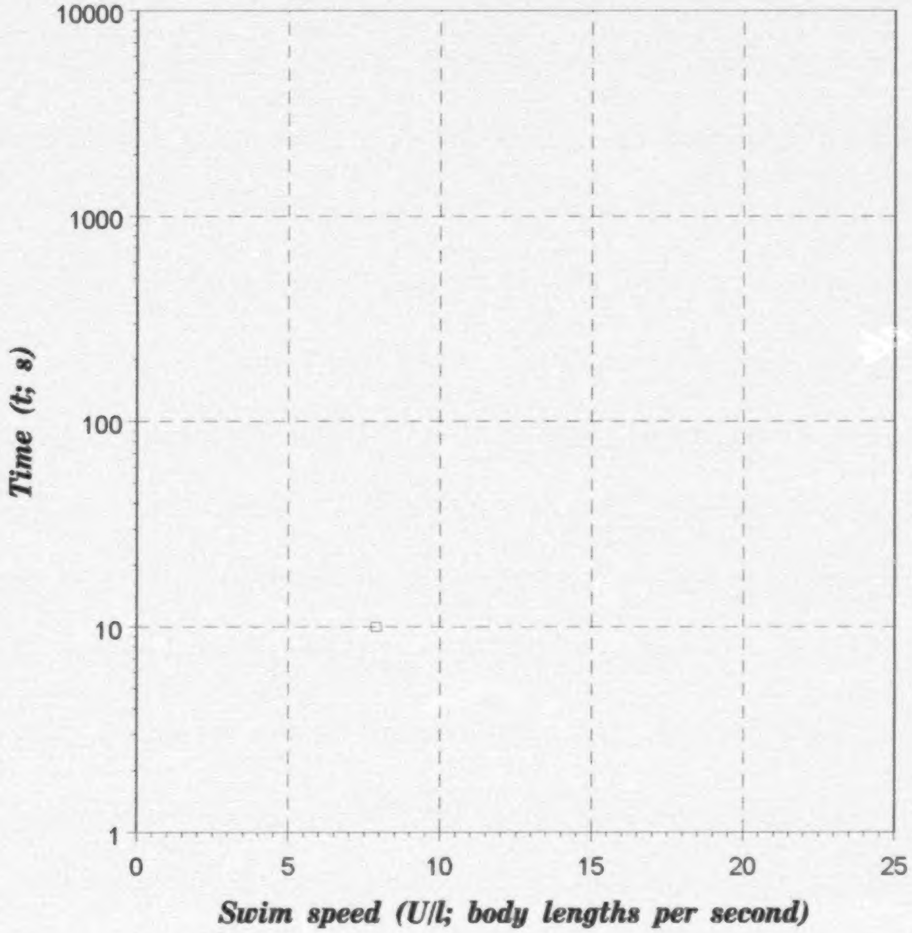


Figure A-104. Preprocessed data for Pimephales vigilax *(Bullhead Minnow): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-104. Swim speed data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.05	0	0.05	0.05	0	1
T (C)	23.4	0	23.4	23.4	0	1
U (m/s)*	0.396	0	0.396	0.396	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

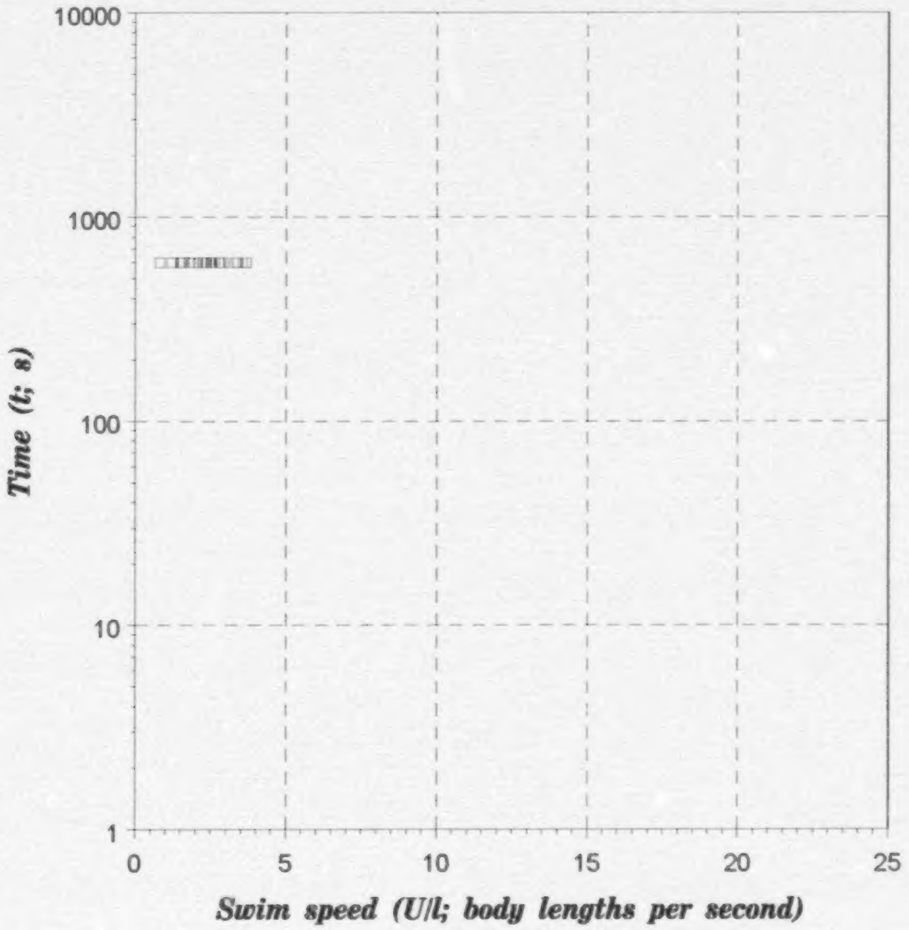


Figure A-105. Preprocessed data for Platygobio gracilus *(Flathead Chub): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973).*

Table A-105. Swim speed data summary. Fish count 26, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.233	0.039	0.17	0.3	0.13	11
T (C)	16	0	16	16	0	1
U (m/s)*	0.556	0.183	0.23	0.88	0.65	19
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

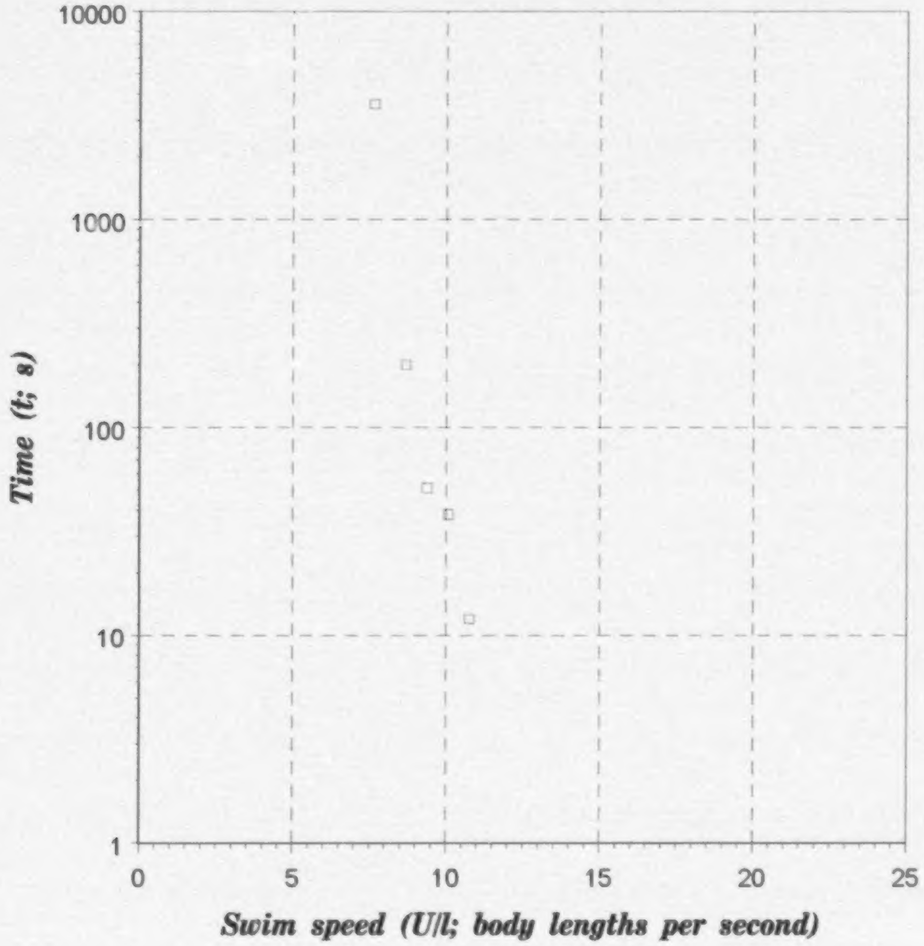


Figure A-106. Preprocessed data for Plecoglossus altivelis *(Ayu): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Tsukamoto (1975).*

Table A-106. Swim speed data summary. Fish count 25, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.144	0	0.144	0.144	0	1
T (C)	18	0	18	18	0	1
U (m/s)*	1.34	0.159	1.1	1.55	0.45	5
t_e (s)	780	1441	12	3600	3588	5
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

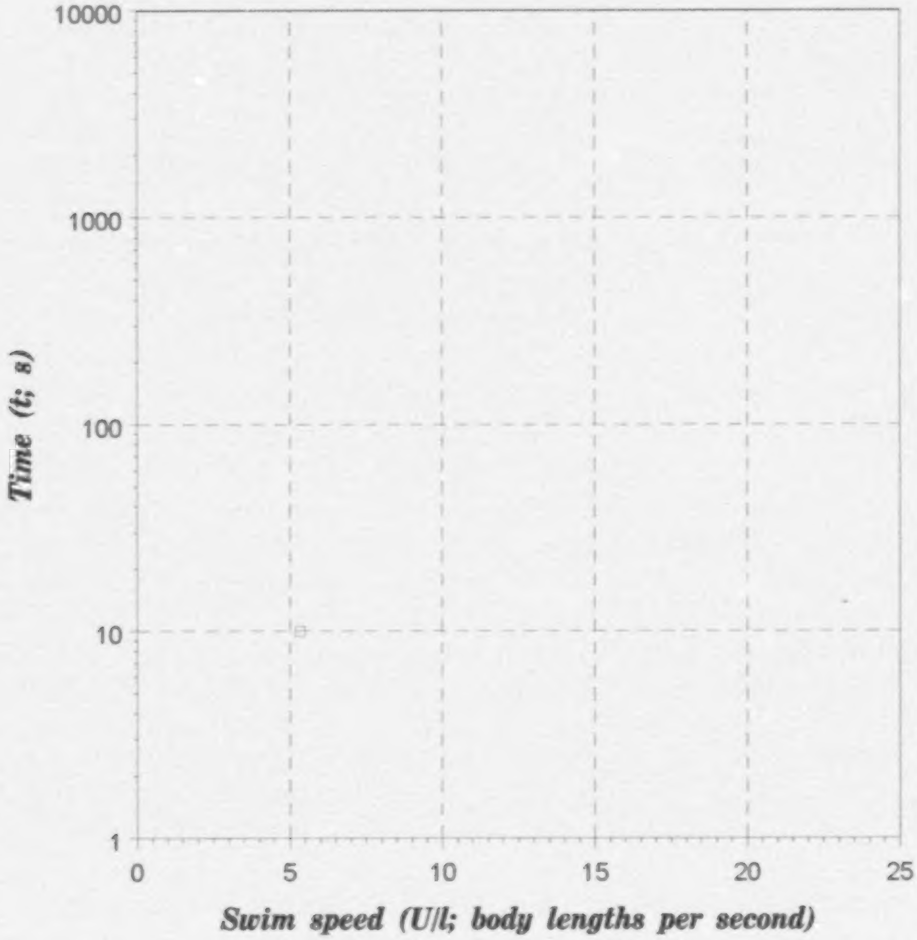


Figure A-107. Preprocessed data for Poecilia latipinna *(Sailfin Molly): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009).*

Table A-107. Swim speed data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	22.7	0	22.7	22.7	0	1
U (m/s)*	0.186	0	0.186	0.186	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

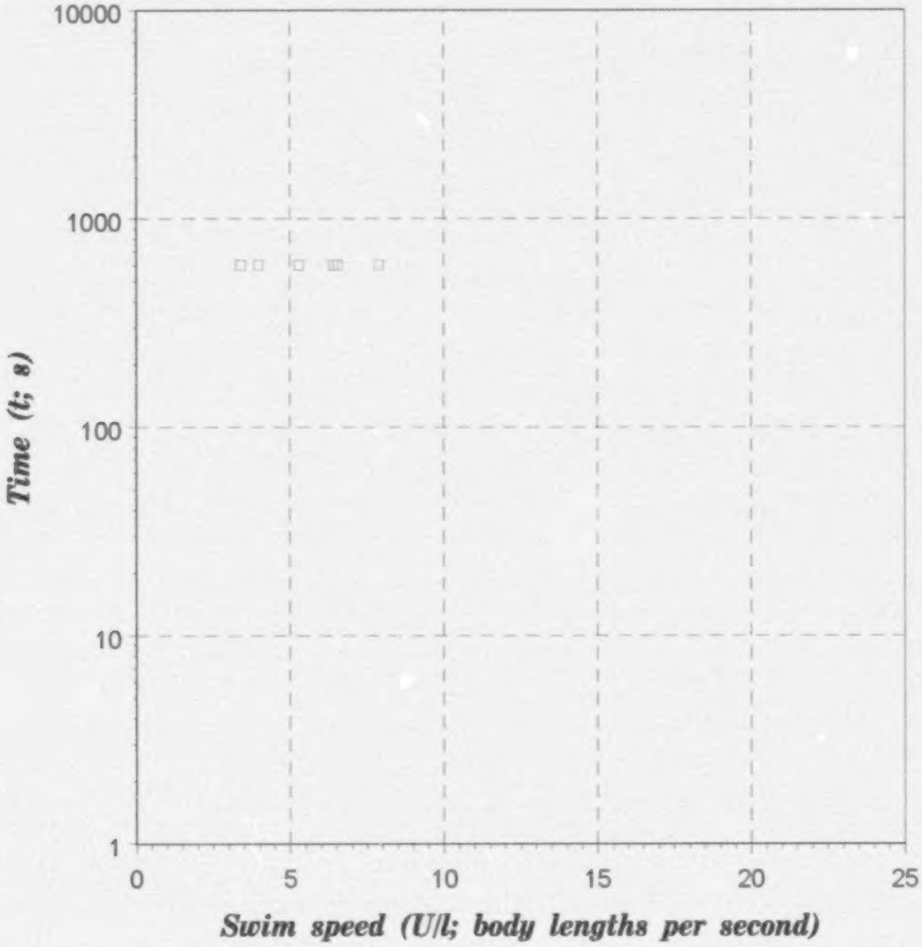


Figure A-108. Preprocessed data for Pogonichthys macrolepidotus *(Sacramento Splittail): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Cech and Young (1995).*

Table A-108. Swim speed data summary. Fish count 66, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.079	0.058	0.029	0.195	0.166	6
T (C)	18	1.4	17	20	3	2
U (m/s)*	0.365	0.152	0.19	0.66	0.47	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

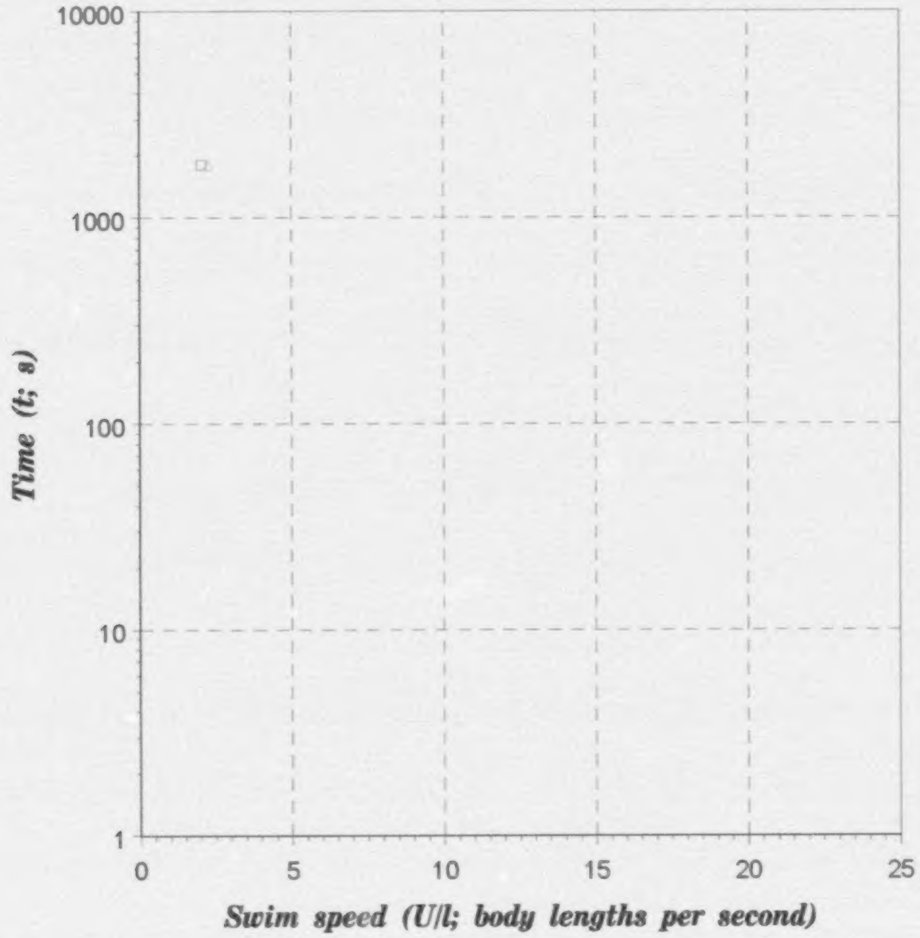


Figure A-109. Preprocessed data for Pomoxis annularis *(White Crappie): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Parsons and Sylvester (1992); red triangle is data from Parsons (1993).*

Table A-109. Swim speed data summary. Fish count 19, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.17	0	0.17	0.17	0	1
T (C)	25	0	25	25	0	1
U (m/s)*	0.362	0	0.347	0.387	0.04	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	1800	0	1800	1800	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

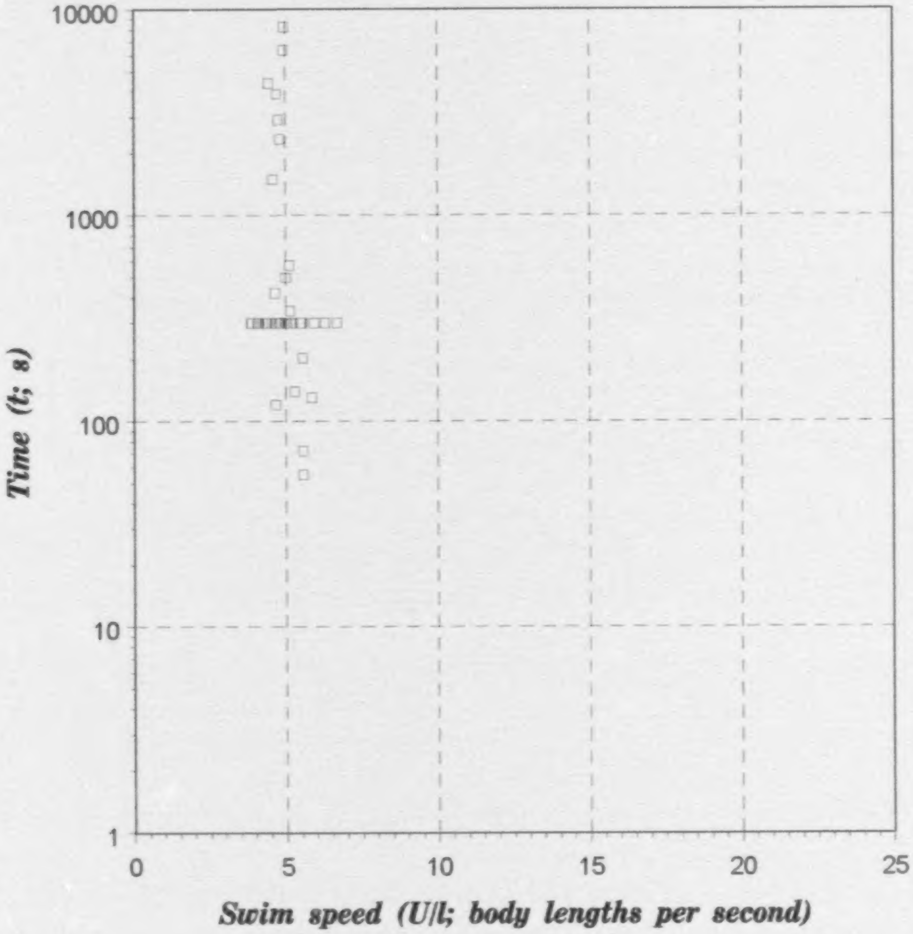


Figure A-110. Preprocessed data for Prochilodus costatus *(Curimba): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Santos et al. (2012).*

Swim speed data summary. Fish count 42, record count 42.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.299	0.025	0.255	0.38	0.125	17
T (C)	24.6	0.2	24.3	25.3	1	9
U (m/s)*	1.463	0.139	1.161	1.771	0.61	39
t_e (s)	1890	2481	55	8220	8165	17
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

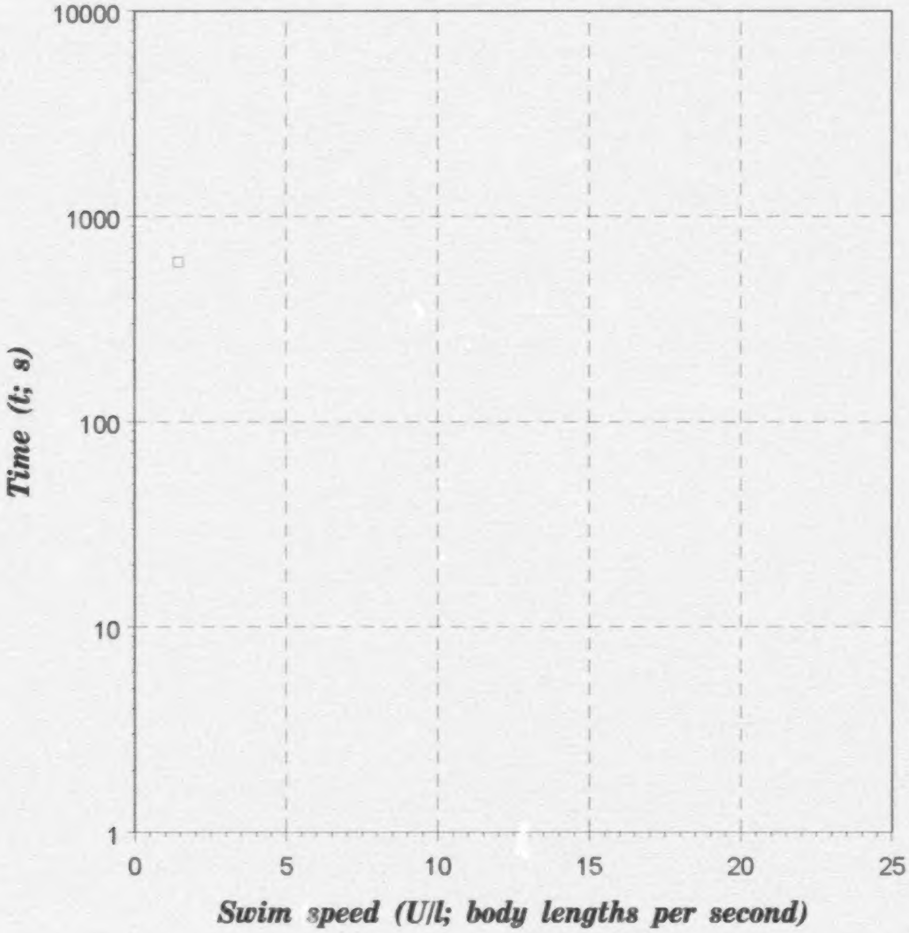


Figure A-111. Preprocessed data for Prosopium williamsoni *(Mountain Whitefish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Jones et al. (1973).*

Table A-111. Swim speed data summary. Fish count 9, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0	0.3	0.3	0	1
T (C)	10	0	10	10	0	1
U (m/s)*	0.43	0	0.43	0.43	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

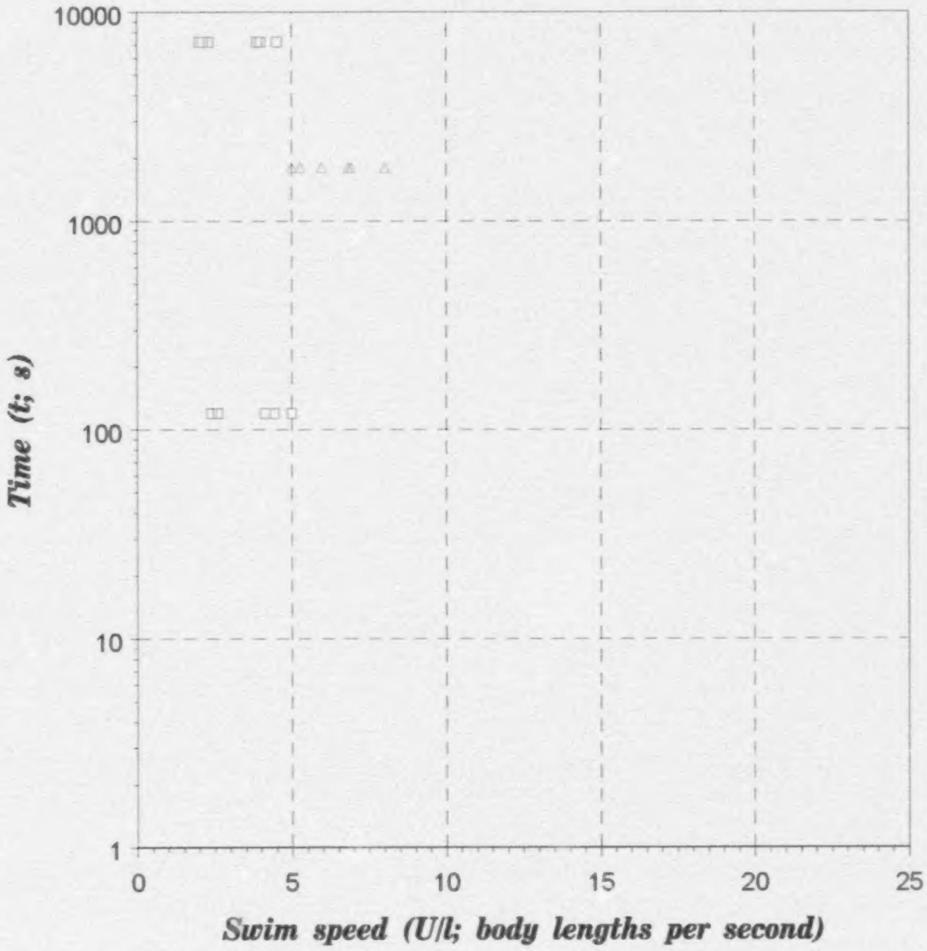


Figure A-112. Preprocessed data for Ptychocheilus lucius *(Colorado Squawfish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Berry and Pimentel (1985); red triangles are data from Childs and Clarkson (1996).*

Table A-112. Swim speed data summary. Fish count 656, record count 18.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.133	0.128	0.022	0.451	0.43	12
T (C)	18.5	5.2	10	26	16	4
U (m/s)*	0.459	0.258	0.133	1.08	0.947	16
t_e (s)	3223	3198	120	7200	7080	3
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

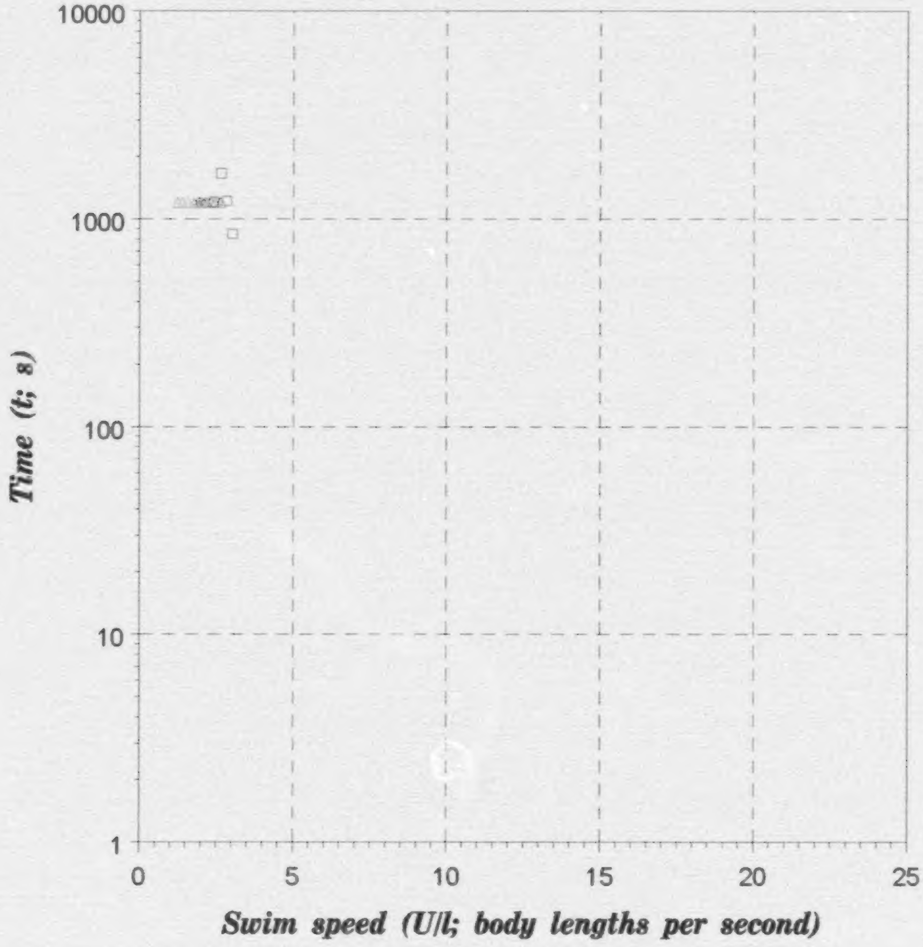


Figure A-113. Preprocessed data for Ptychocheilus oregonensis *(Northern Squawfish): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Mesa and Olson (1993); red triangles are data from Kolok and Farrell (1994a); green stars are data from Kolok and Farrell (1994b).*

Table A-113. Swim speed data summary. Fish count 106, record count 27.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.35	0.061	0.25	0.435	0.185	5
T (C)	14.5	3.8	5	18	13	4
U (m/s)*	0.857	0.252	0.309	1.15	0.841	27
t_e (s)	1242	299	846	1662	816	4
$t_{\Delta t}$ (s)**	1200	0	1200	1200	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

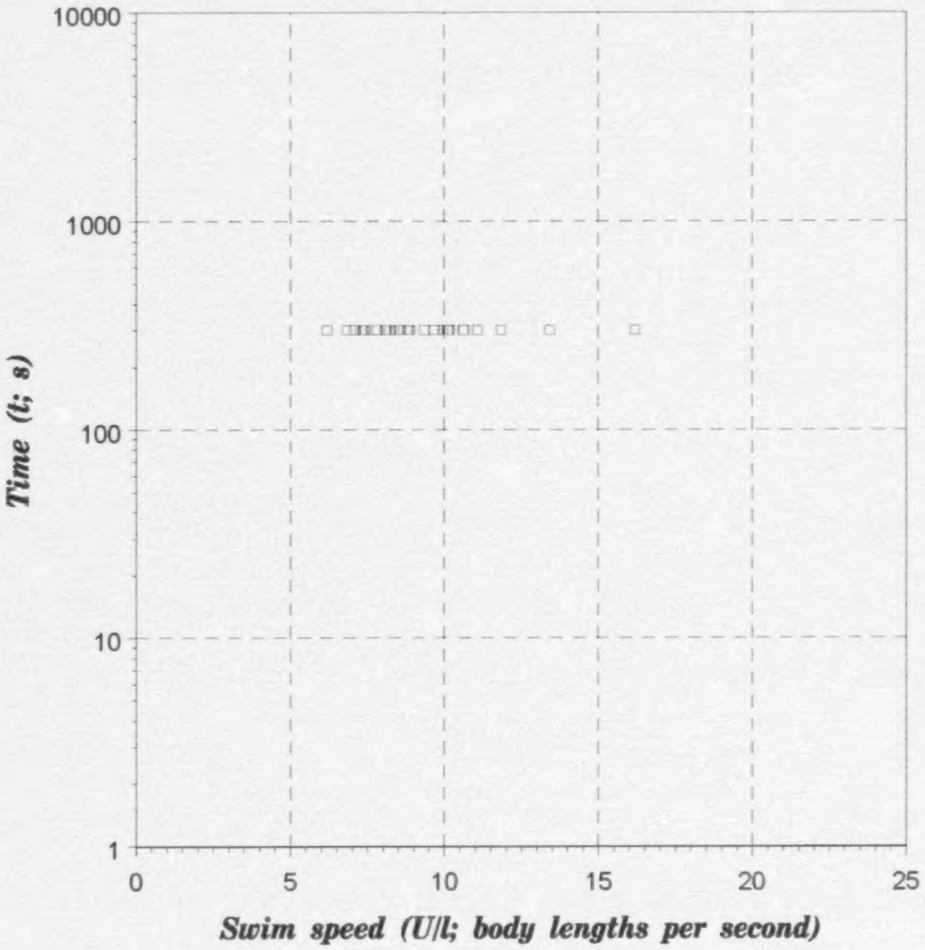


Figure A-114. Preprocessed data for Rhinichthys atratulus *(Blacknose Dace): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Nelson et al. (2003).*

Table A-114. Swim speed data summary. Fish count 32, record count 32.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0.001	0.041	0.044	0.003	5
T (C)	24	0	24	24	0	1
U (m/s)*	0.387	0.087	0.265	0.69	0.425	31
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

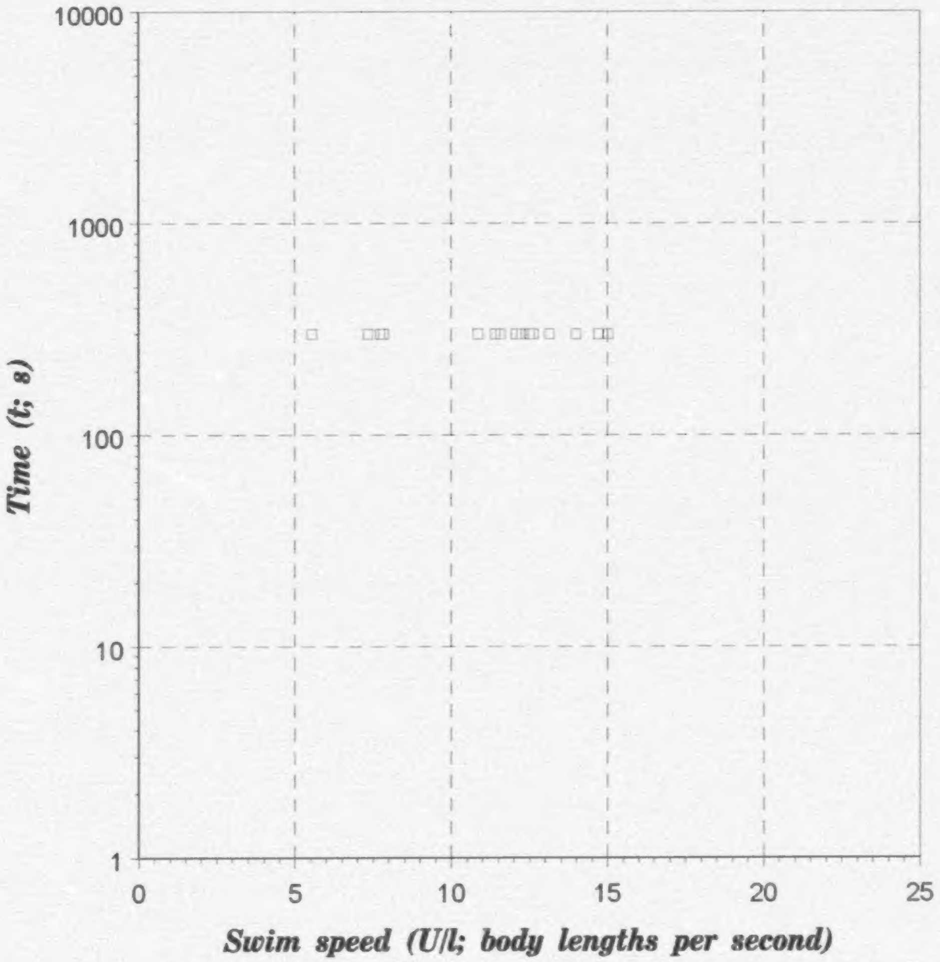


Figure A-115. Preprocessed data for Rhinichthys cataractae *(Longnose Dace): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Aedo et al. (2009).*

Table A-115. Swim speed data summary. Fish count 15, record count 15.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.066	0.017	0.04	0.087	0.047	13
T (C)	17	0	17	17	0	1
U (m/s)*	0.727	0.229	0.329	1.066	0.737	15
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

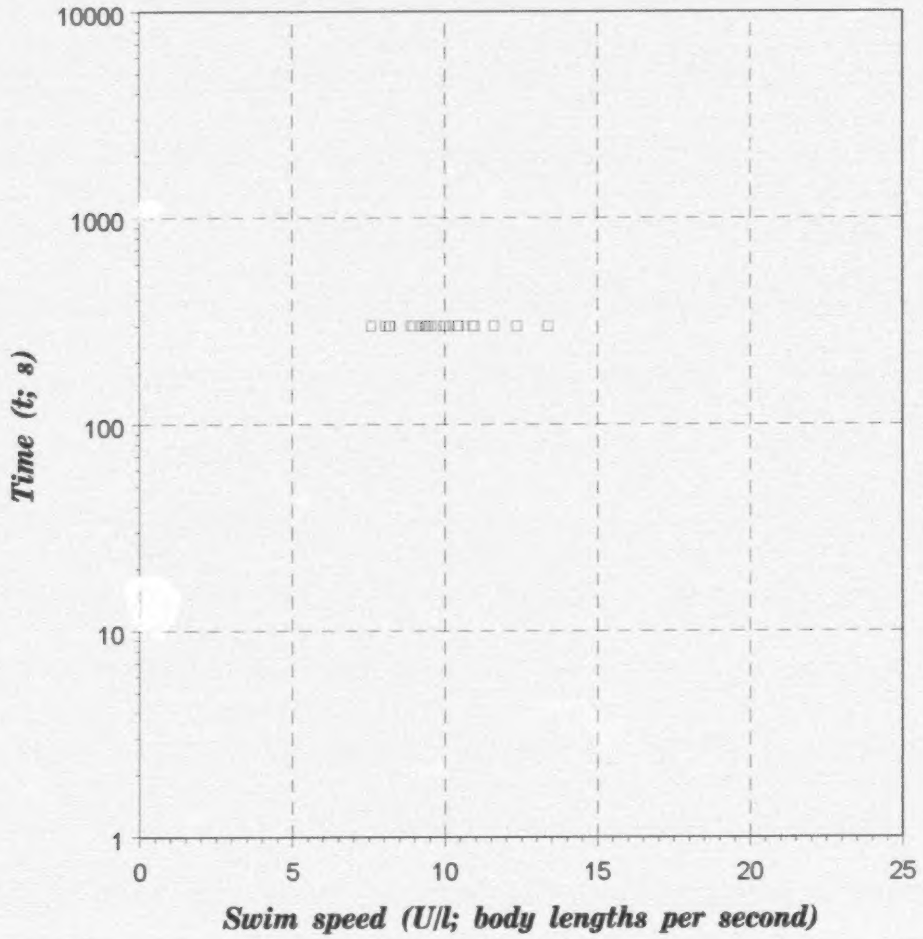


Figure A-116. Preprocessed data for Rhinichthys osculus *(Speckled Dace): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Aedo et al. (2009).*

Table A-116. Swim speed data summary. Fish count 20, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.071	0.012	0.046	0.085	0.039	15
T (C)	17	0	17	17	0	1
U (m/s)*	0.694	0.155	0.432	1.004	0.572	19
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

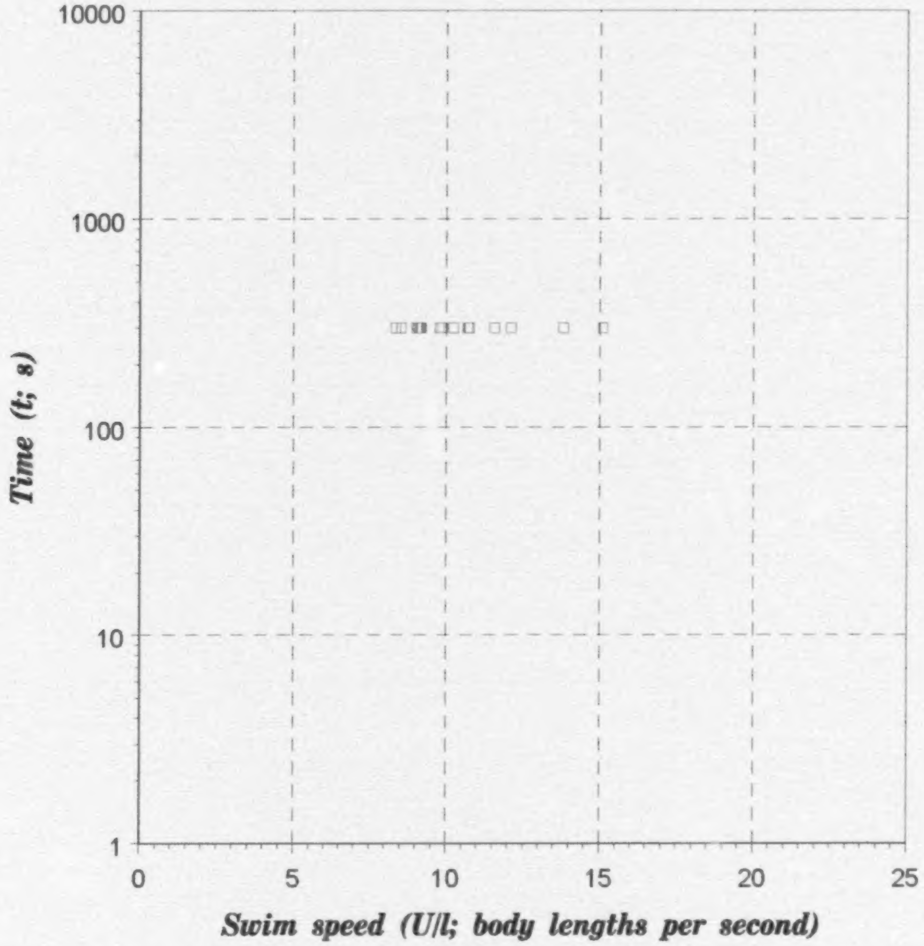


Figure A-117. Preprocessed data for Richardsonius balteatus *(Redside Shiner): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Aedo et al. (2009).*

Table A-117. Swim speed data summary. Fish count 18, record count 18.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.074	0.022	0.034	0.112	0.078	16
T (C)	17	0	17	17	0	1
U (m/s)*	0.755	0.219	0.33	1.042	0.712	16
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	300	0	300	300	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

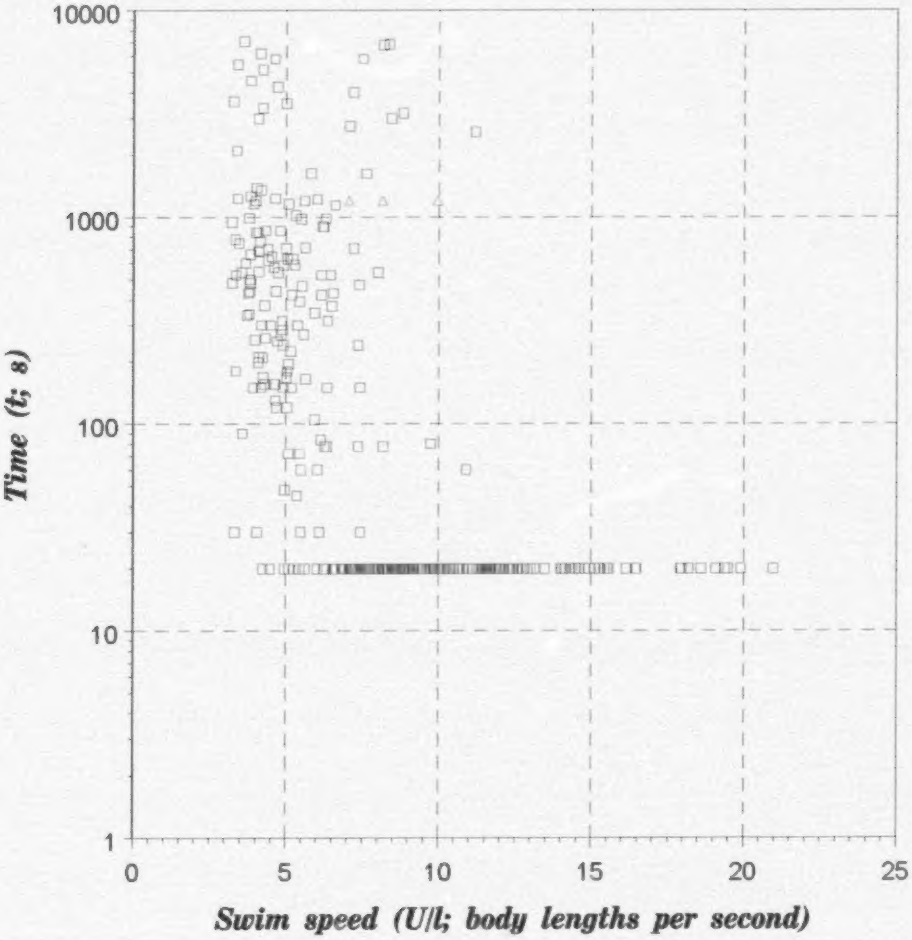


Figure A-118. Preprocessed data for Rutilus rutilus *(Roach): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Clough and Tumpenny (2000); red triangles are data from Tudoraache et al. (2008).*

Table A-118. Swim speed data summary. Fish count 375, record count 354.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.128	0.039	0.046	0.208	0.162	128
T (C)	14	3.4	8.8	21.2	12.4	30
U (m/s)*	0.983	0.355	0.4	1.995	1.595	131
t_e (s)	1045	1550	30	7080	7050	100
$t_{\Delta t}$ (s)**	141	359	20	1200	1180	2

* U=critical velocity (U_{crit})
** t=time step (Δt)

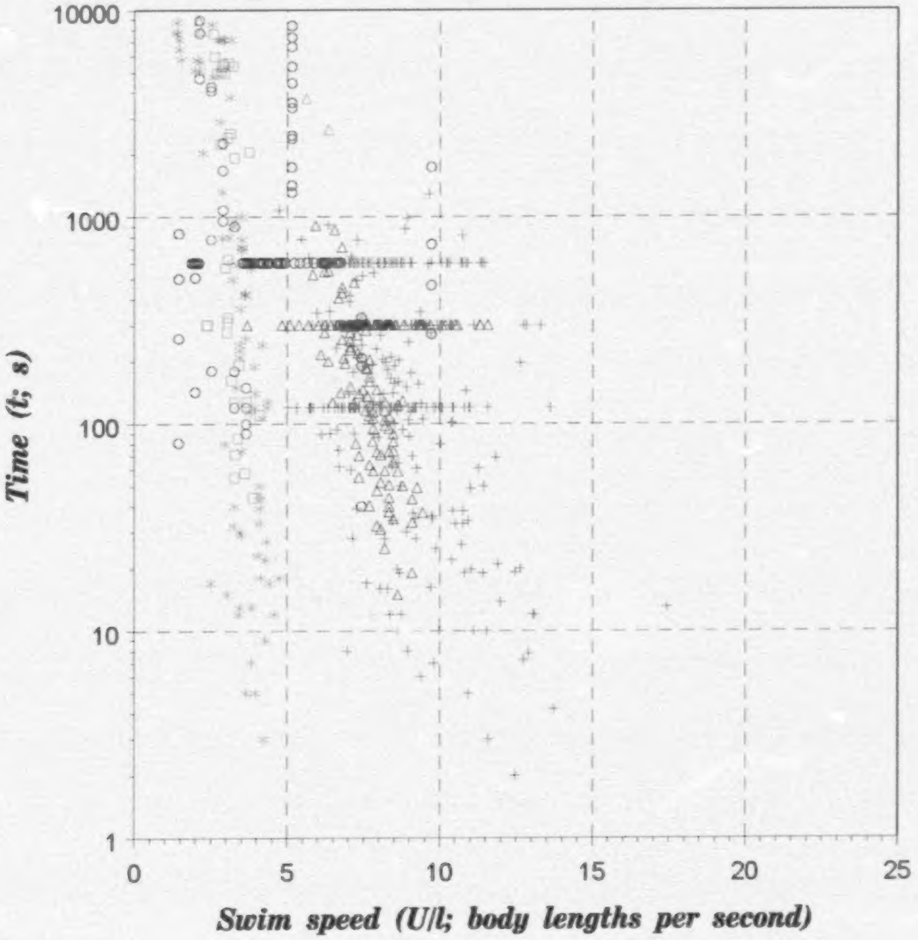


Figure A-119. Preprocessed data for Salmo salar *(Atlantic Salmon) swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from McCleave and Stred (1975); red triangles are data from Tang and Wardle (1992); green stars are data from Booth et al. (1997a); black circles are data from Booth et al. (1997b); turquoise diamonds are data from Colavecchia (1997); blue crosses are data from Peake et al. (1997b); red x's are data from Peake et al (1997c); black squares are data from Thorstad et al. (1997); black triangles are data from McDonald et al.(1998); turquoise stars are data from Beddow and Mckinley (1999); blue circles are data from Thorstad et al. (2000).*

Table A-119. Swim speed data summary. Fish count 1106, record count 673.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.24	0.194	0.048	0.64	0.592	212
T (C)	12.1	4.7	3.5	20.5	17	51
U (m/s)*	1.367	0.794	0.195	4.53	4.335	300
t_e (s)	1143	1966	2	8964	8962	290
$t_{\Delta t}$ (s)**	439	182	120	600	480	3

* U=critical velocity (U_{crit})

** t=time step (Δt)

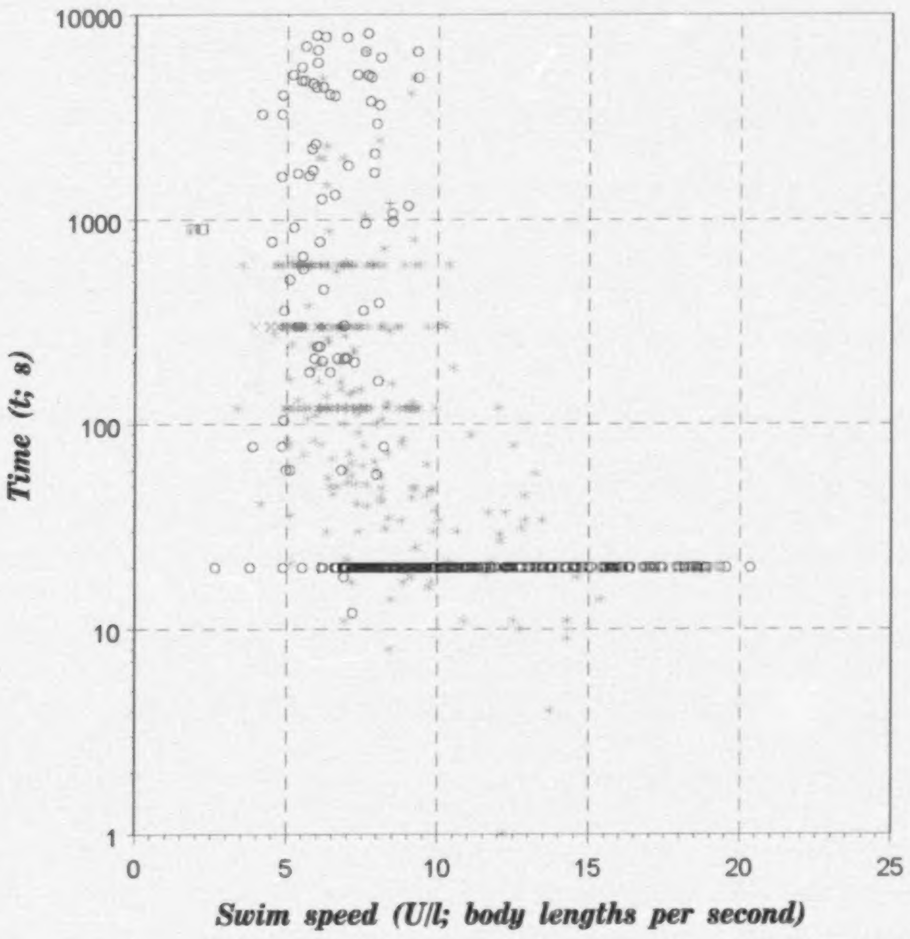


Figure A-120. Preprocessed data for Salmo trutta *(Brown Trout): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Butler et al. (1992); red triangles are data from Beaumont et al. (1995a); green stars are data from Peake et al. (1997b); black circles are data from Clough and Tumpenny (2000); turquoise diamonds are data from Ojanguran and Brana (2003); blue crosses are data from Tudorache et al. (2008); red x's are data from Aedo et al. (2009).*

Table A-120. Swim speed data summary. Fish count 739, record count 685.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.152	0.074	0.047	0.4	0.353	250
T (C)	11.6	4.8	5	21.2	16.2	35
U (m/s)*	1.06	0.447	0.316	2.3	1.984	293
t_e (s)	901	1760	1	8100	8099	202
$t_{\Delta t}$ (s)**	245	326	20	1200	1180	6

* U=critical velocity (U_{crit})

** t=time step (Δt)

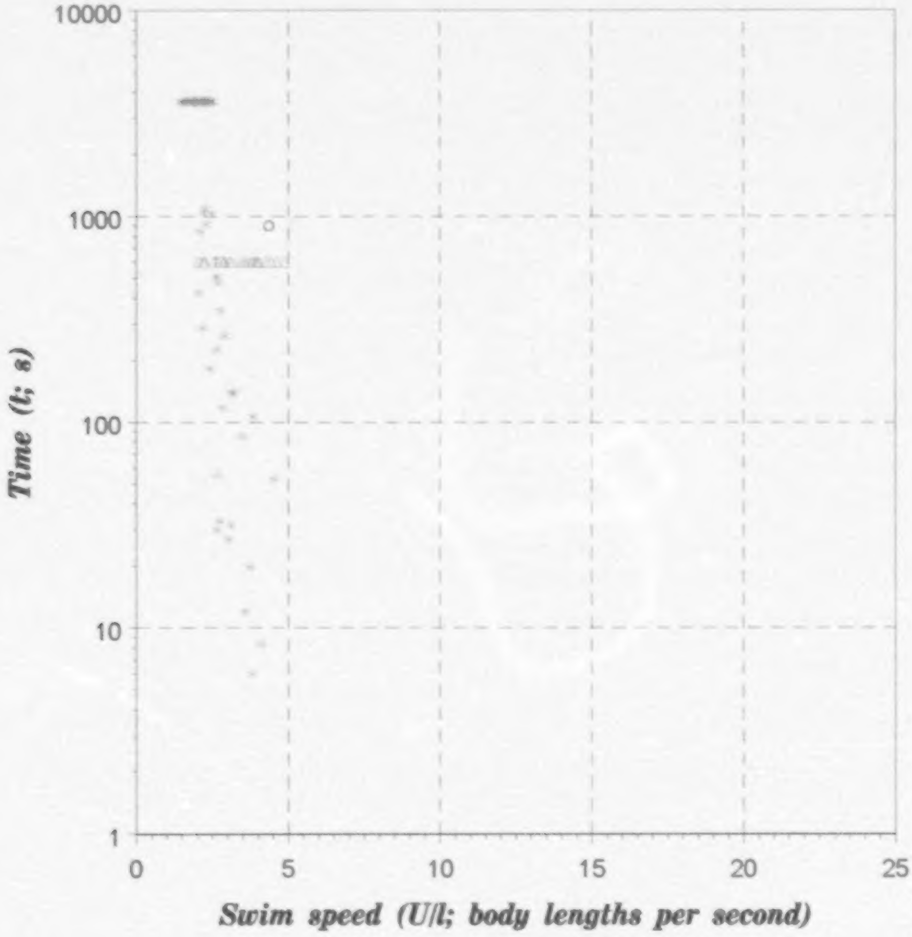


Figure A-121. Preprocessed data for Salvelinus alpinus *(Arctic Char): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Jones et al. (1973); red triangles are data from Welch (1979); green stars are data from Beamish (1980); black circles are data from Hunter and Scherer (1988); turquoise diamonds are data from Jones and Moffitt (2004).*

Table A-121. Swim speed data summary. Fish count 184, record count 89.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.242	0.084	0.074	0.411	0.337	69
T (C)	10.9	2.8	5	15	10	5
U (m/s)*	0.856	0.203	0.3	1.3	1	52
t_e (s)	617	295	6	1089	1083	31
$t_{\Delta t}$ (s)**	1808	1444	600	3600	3000	3

* U=critical velocity (U_{crit})
** t=time step (Δt)

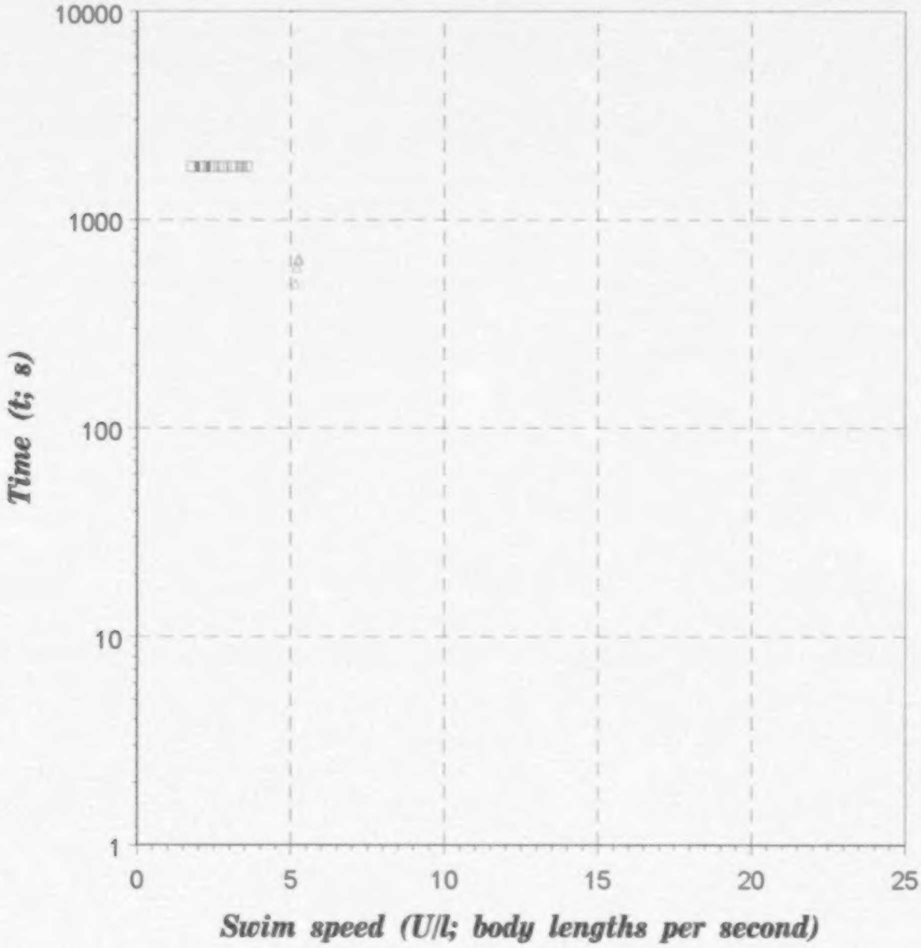


Figure A-122. Preprocessed data for Salvelinus confluentus *(Bull Trout): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Mesa et al. (2003b); red triangles are data from Jones and Moffitt (2004).*

Table A-122. Swim speed data summary. Fish count 106, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.207	0.046	0.109	0.425	0.316	19
T (C)	12.3	2.9	9	15	6	3
U (m/s)*	0.977	0.193	0.272	1.15	0.878	19
t_e (s)	598	60	494	647	153	1
$t_{\Delta t}$ (s)**	1800	0	1800	1800	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

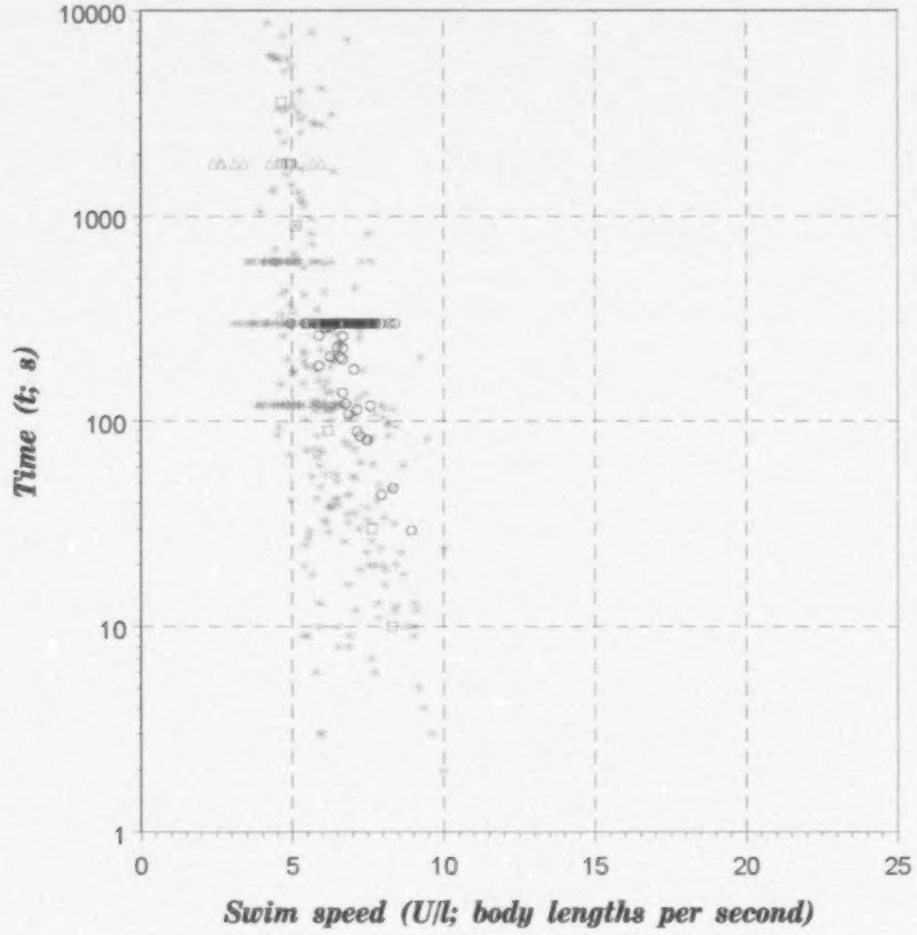


Figure A-123. Preprocessed data for Salvelinus fontinalis *(Brook Trout): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Peterson (1974); red triangles are data from Beamish (1980); green stars are data from Peake et al. (1997b); black circles are data from McDonald et al. (1998); turquoise diamonds are from Paul et al. (2005).*

Table A-123. Swim speed data summary. Fish count 507, record count 429.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.132	0.063	0.037	0.405	0.368	205
T (C)	16	2.8	9.5	20	10.5	25
U (m/s)*	0.762	0.345	0.202	1.843	1.641	192
t_e (s)	689	1498	2	8729	8727	184
$t_{\Delta t}$ (s)**	685	755	10	3600	3590	9

* U=critical velocity (U_{crit})

** t=time step (Δt)

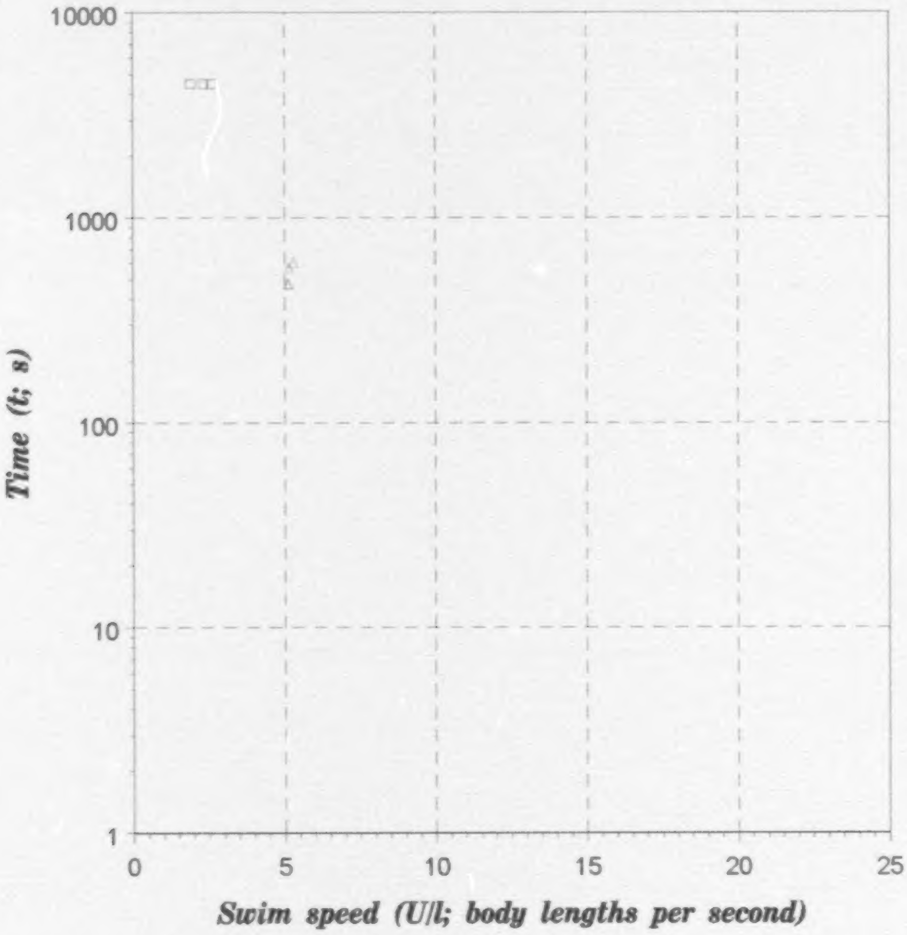


Figure A-124. Preprocessed data for Salvelinus namaycush *(Lake Trout): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Beamish (1980); red triangles are data from Jones and Moffitt (2004).*

Table A-124. Swim speed data summary. Fish count 119, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.181	0.042	0.115	0.225	0.11	5
T (C)	12.1	3.4	5	15	10	4
U (m/s)*	0.856	0.345	0.22	1.15	0.93	6
t_e (s)	538	58	473	603	130	4
$t_{\Delta t}$ (s)**	4500	0	4500	4500	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

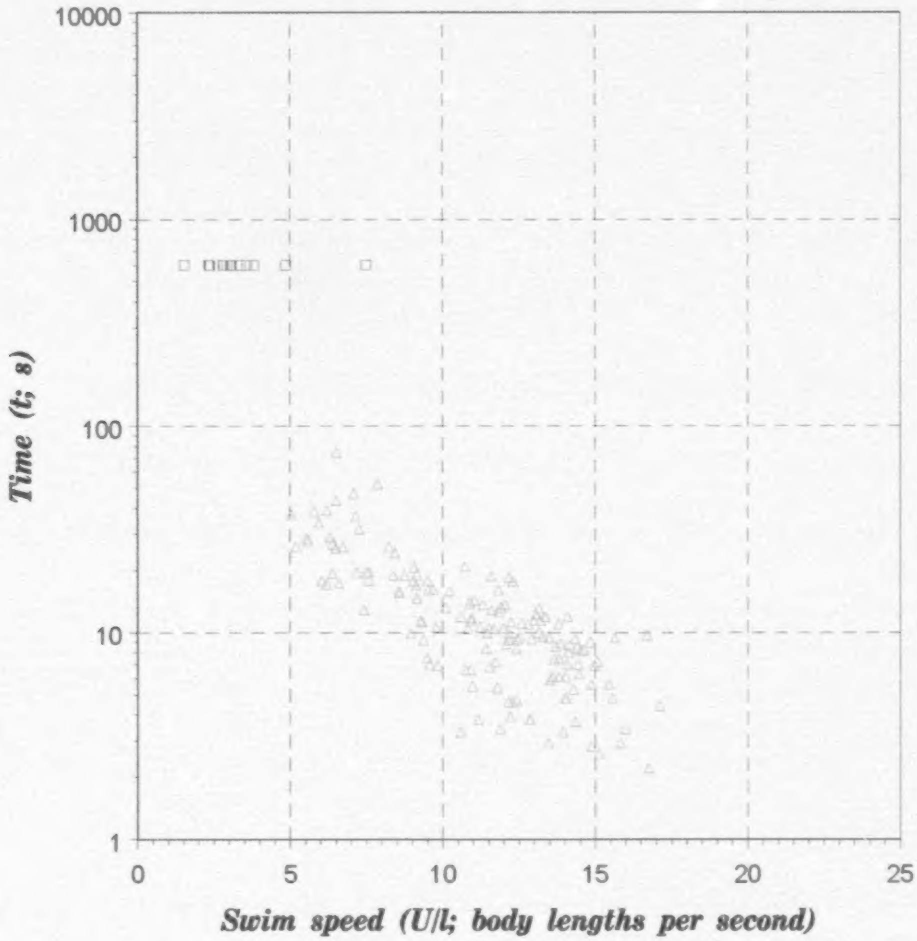


Figure A-125. Preprocessed data for Sander vitreus *(Walleye): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973); red triangles are data from Castro-Santos (2005).*

Table A-125. Swim speed data summary. Fish count 161, record count 161.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.309	0.035	0.07	0.318	0.248	9
T (C)	14.2	1.9	13.6	20	6.4	2
U (m/s)*	3.304	1.229	0.28	5.44	5.16	136
t_e (s)	14	11	2	74	72	96
$t_{\Delta t}$ (s	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

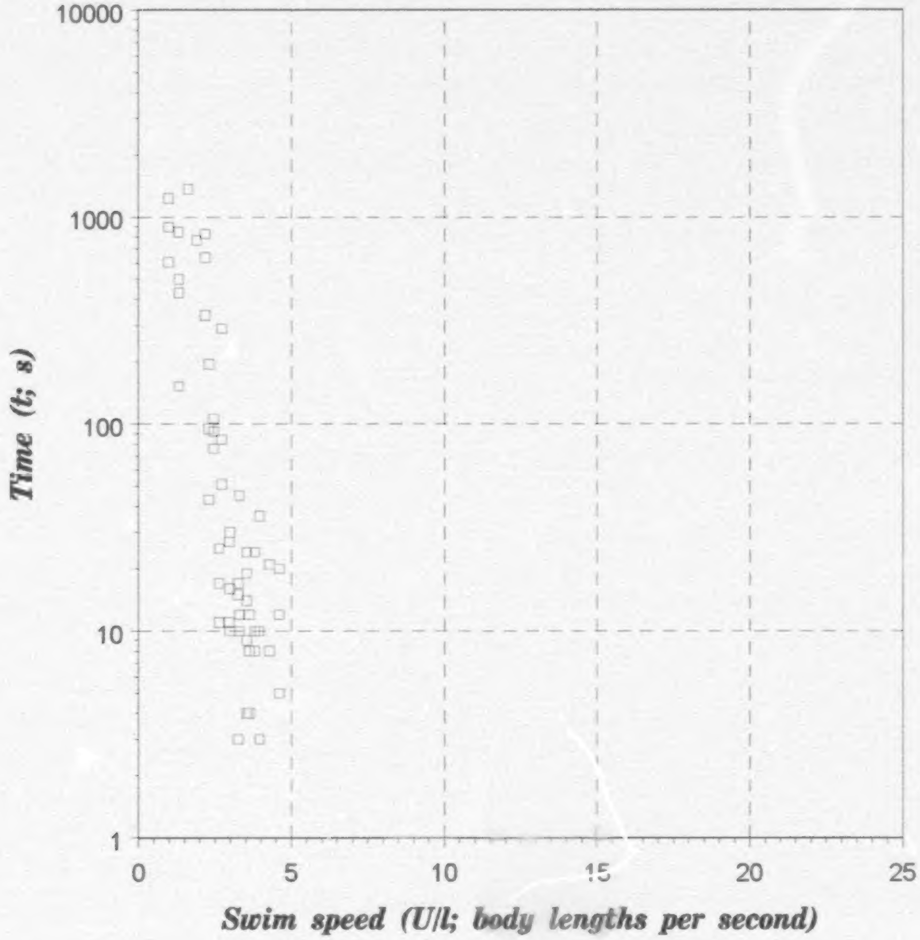


Figure A-126. Preprocessed data for Scaphirhynchus albus *(Pallid Sturgeon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Adams et al. (1999).*

Table A-126. Swim speed data summary. Fish count 54, record count 54.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.167	0.016	0.152	0.184	0.032	2
T (C)	18.5	0	18.5	18.5	0	1
U (m/s)*	0.486	0.162	0.15	0.7	0.55	11
t_e (s)	188	331	3	1362	1359	42
$t_{\Delta t}$ (s)**	.	.	.	.	.	0

* U=fixed velocity
** t=time step (Δt)

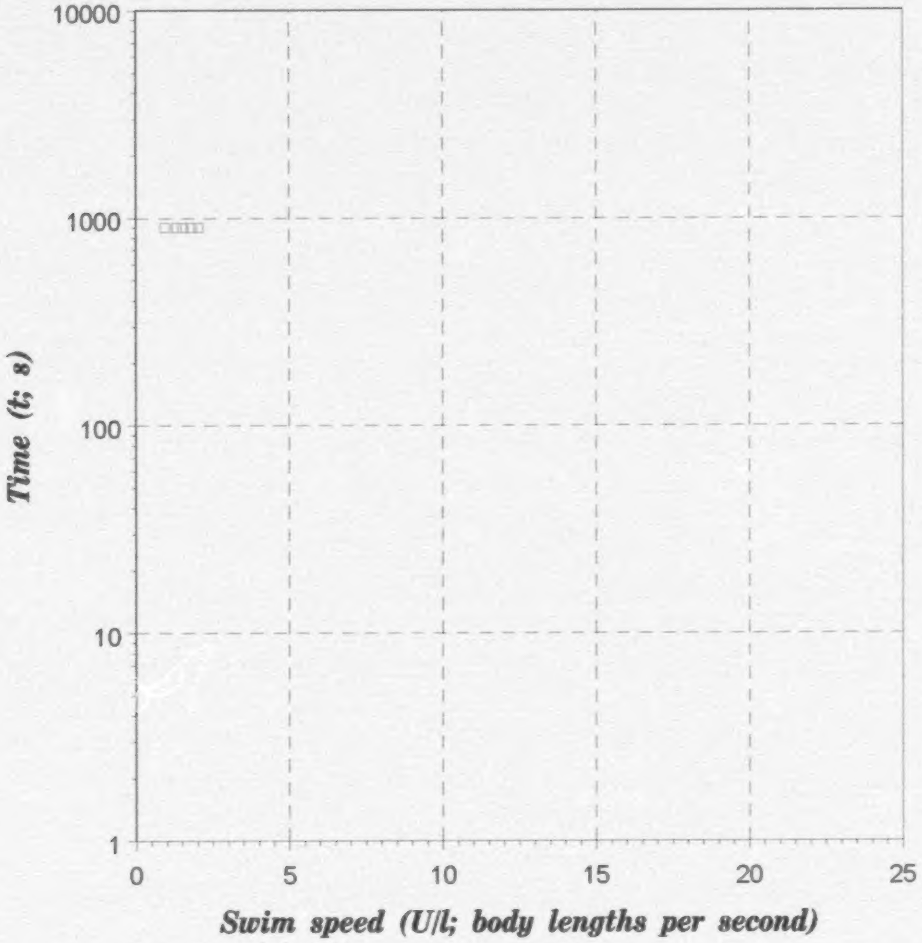


Figure A-127. Preprocessed data for Scaphirhynchus platorynchus *(Shovelnose Sturgeon): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Adams et al. (1997).*

Table A-127. Swim speed data summary. Fish count 5, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.631	0.058	0.57	0.69	0.12	4
T (C)	16	0	16	16	0	1
U (m/s)*	0.953	0.216	0.647	1.16	0.513	4
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	900	0	900	900	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

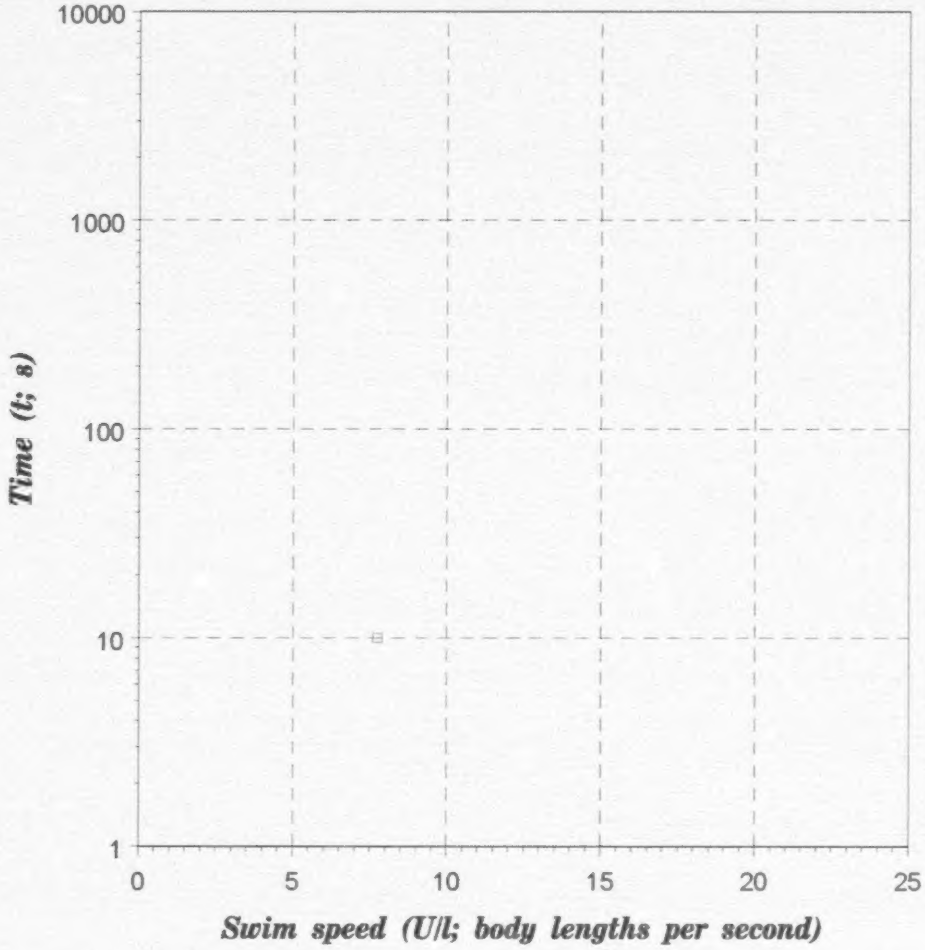


Figure A-128. Preprocessed data for Semotilus atromaculatus *(Creek Chub): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue square is data from Leavy and Bonner (2009)*

Table A-128. Swim speed data summary. Fish count 9, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.057	0	0.057	0.057	0	1
T (C)	28.5	0	28.5	28.5	0	1
U (m/s)*	0.442	0	0.442	0.442	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	10	0	10	10	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

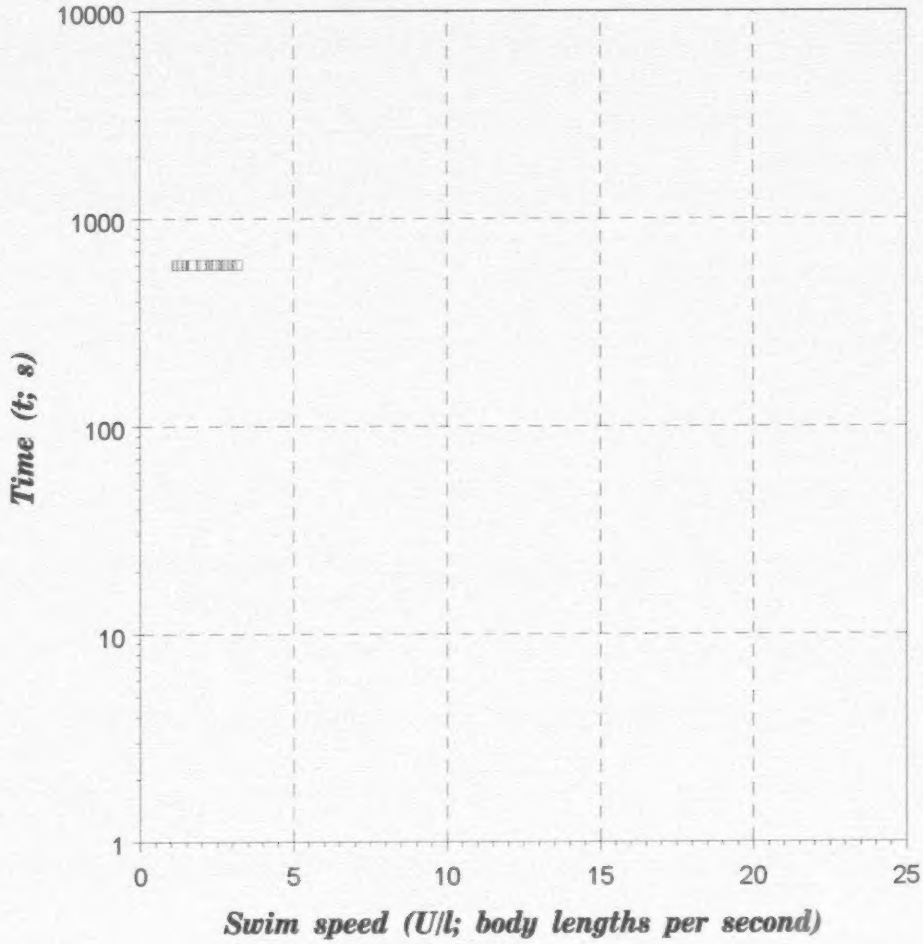


Figure A-129. Preprocessed data for Stenodus leucichthys *(Inconnu): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973).*

Table A-129. Swim speed data summary. Fish count 19, record count 19.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.296	0.086	0.17	0.41	0.24	11
T (C)	16	0	16	16	0	1
U (m/s)*	0.604	0.217	0.25	0.99	0.74	17
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

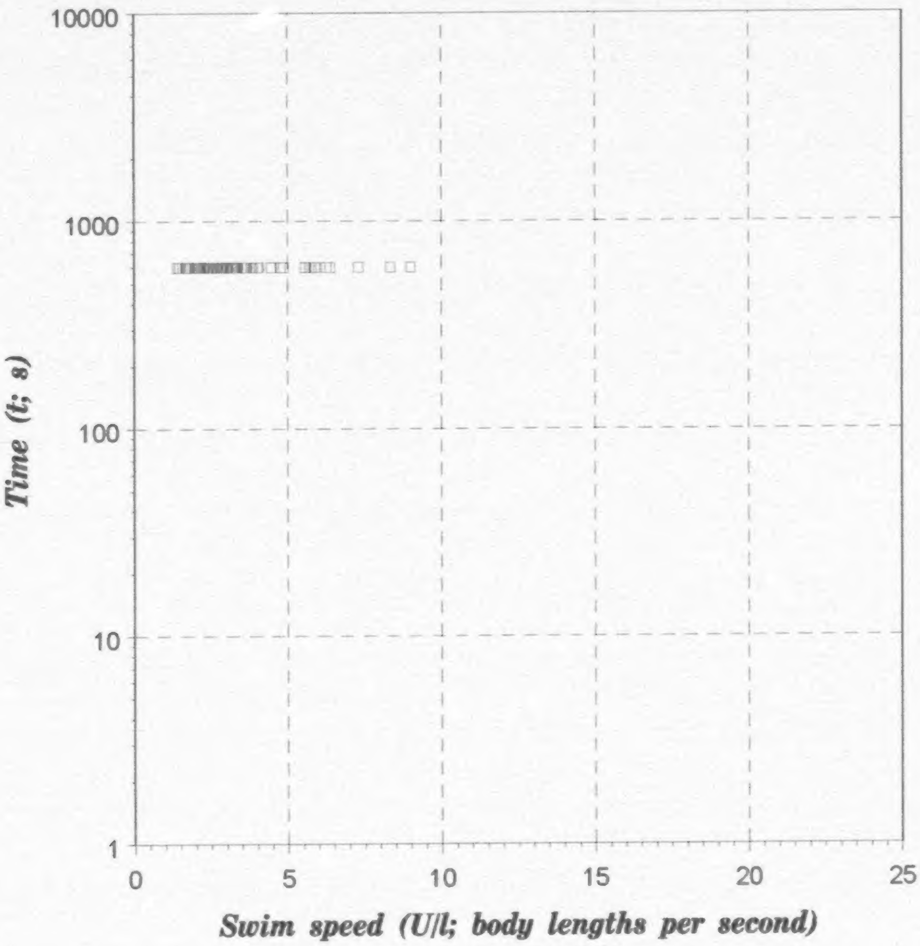


Figure A-130. Preprocessed data for Thymallus arcticus *(Arctic Grayling): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Jones et al. (1973).*

Table A-130. Swim speed data summary. Fish count 89, record count 89.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.227	0.071	0.06	0.36	0.3	24
T (C)	16	0	16	16	0	1
U (m/s)*	0.673	0.169	0.3	1.07	0.77	49
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)**	600	0	600	600	0	1

* U=critical velocity (U_{crit})
** t=time step (Δt)

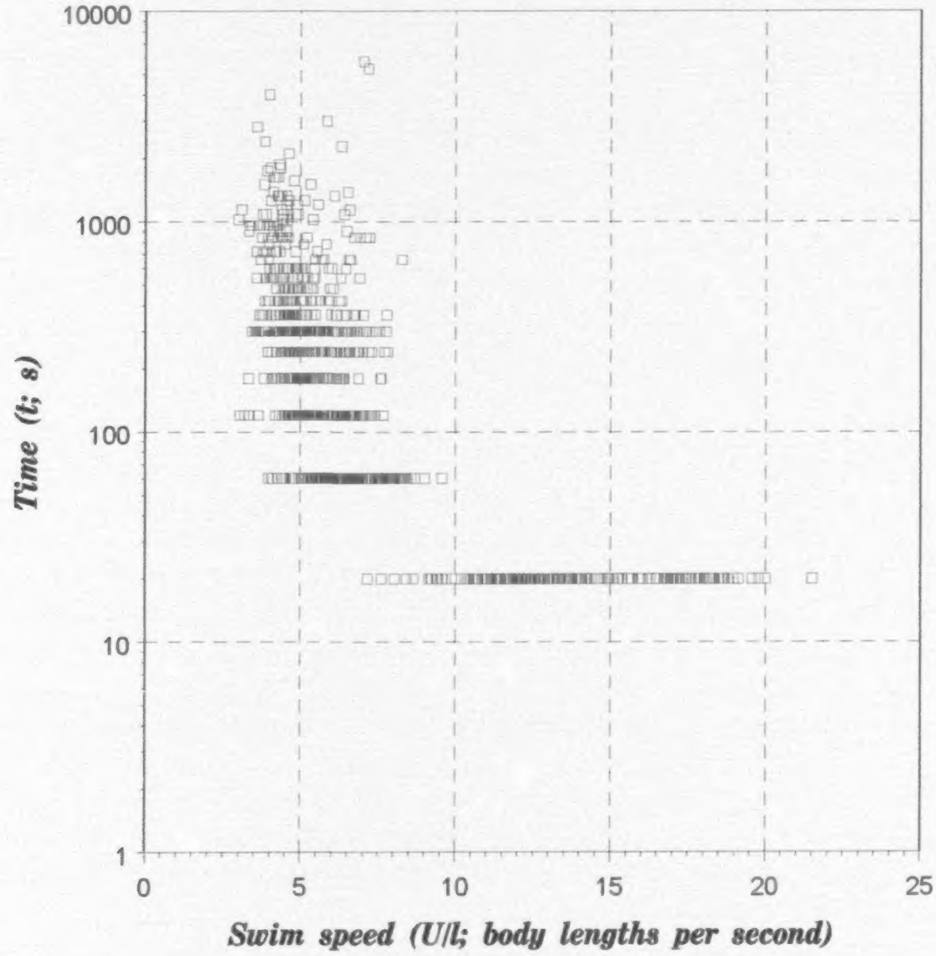


Figure A-131. Preprocessed data for Thymallus thymallus *(European Grayling): swim speed versus time-to-fatigue, where time (t) ≤150 minutes. Blue squares are data from Clough et al. (2003).*

Table A-131. Swim speed data summary. Fish count 1654, record count 1654.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.167	0.083	0.06	0.38	0.32	247
T (C)	12	4.3	4.6	20.9	16.3	147
U (m/s)*	0.835	0.544	0.216	3.03	2.814	296
t_e (s)	675	991	60	9000	8940	71
$t_{\Delta t}$ (s)**	20	0	20	20	0	1

* U=critical velocity (U_{crit})

** t=time step (Δt)

APPENDIX 1–SERIES B

Processed Endurance Data

Swim Speed (*U/l; body lengths/second*) vs Time-to-Fatigue (*t; seconds*)

Plotted by Species and Reference (122 graphs)

- This series of graphs is based on processed swimming speed and time-to-fatigue data, plotted by species (scientific name) and reference (data source). These plots are a variation of the traditional fatigue curve with swimming speed in body lengths per second plotted on the x-axis and time-to-fatigue in seconds on the y-axis with both axes in logarithmic scale. These plots include data from fixed (time-to-fatigue; volitional) and increasing (critical swimming speed) velocity tests. The dependent variable is swim speed for the increasing velocity test and endurance time for the fixed velocity and volitional tests. For our analysis, swim speed was placed on the y-axis and time-to-fatigue on the x-axis which is the reverse of the traditional fatigue curve; however our analysis included critical velocity test data where speed is the dependent variable. More details about the analysis are contained in the report.
- The term processed data has been used to identify the collection of swimming performance data that was derived through additional grouping and screening of the original preprocessed data. Grouping was used to combine individual fish measurement data found in some data sources (references) to treat the data more evenly and develop more consistency in the data used in the analysis. Details on grouping are provided in the report.
- Time-to-fatigue data were limited to 30 minutes or less in these plots for practical reasons (see report for a discussion of the data selection process). It is worth noting that this is a shorter fatigue time than that used in Appendix A – Series A graphs (150 minutes).
- Regression lines have been fitted through the data points for each graph (species) with the 95% prediction interval. For some graphs, the regressions are not valid due to limited data, so those are not included here.

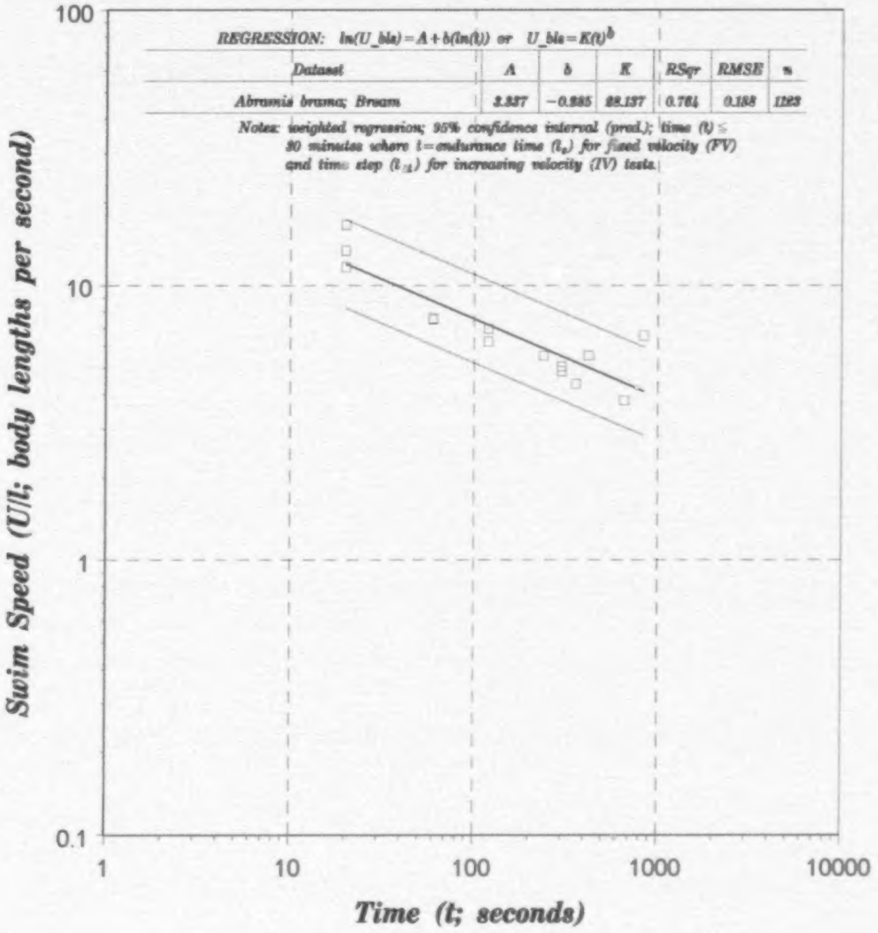


Figure B-001. Processed data for Abramis brama *(Bream): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Clough et al. (2003).*

Table B-001. Data summary. Fish count 1123, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.082	0.003	0.074	0.093	0.019	10
T (C)	12.4	5.1	5.9	19.3	13.4	14
U (m/s)	0.563	0.278	0.305	1.31	1.005	10
t_e (s)	358	200	60	840	780	8
$t_{\Delta t}$ (s)	20	0	20	20	0	1

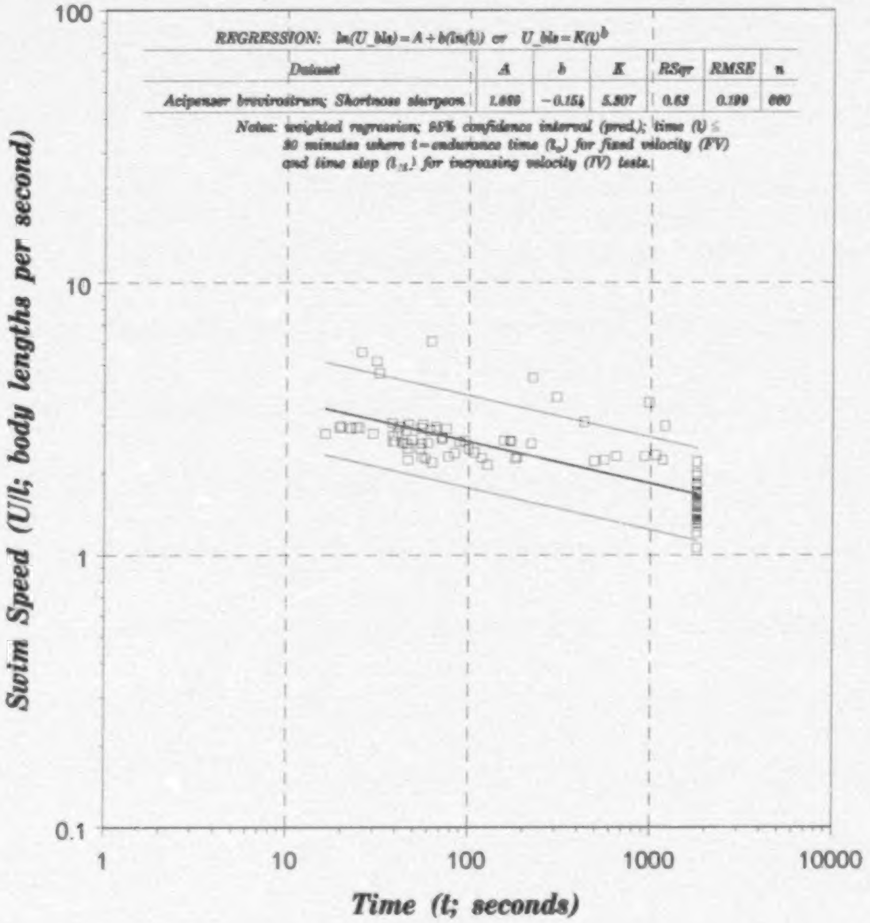


Figure B-002. Processed data for Acipenser brevirostrum *(Shortnose Sturgeon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Deslauriers (2011).*

Table B-002. Data summary. Fish count 660, record count 130

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.163	0.032	0.066	0.211	0.145	47
T (C)	15	6.2	5	25	20	5
U (m/s)	0.358	0.065	.021	0.45	0.24	52
t_e (s)	206	353	16	1797	1781	62
$t_{\Delta t}$ (s)	1786	92	1200	1800	600	2

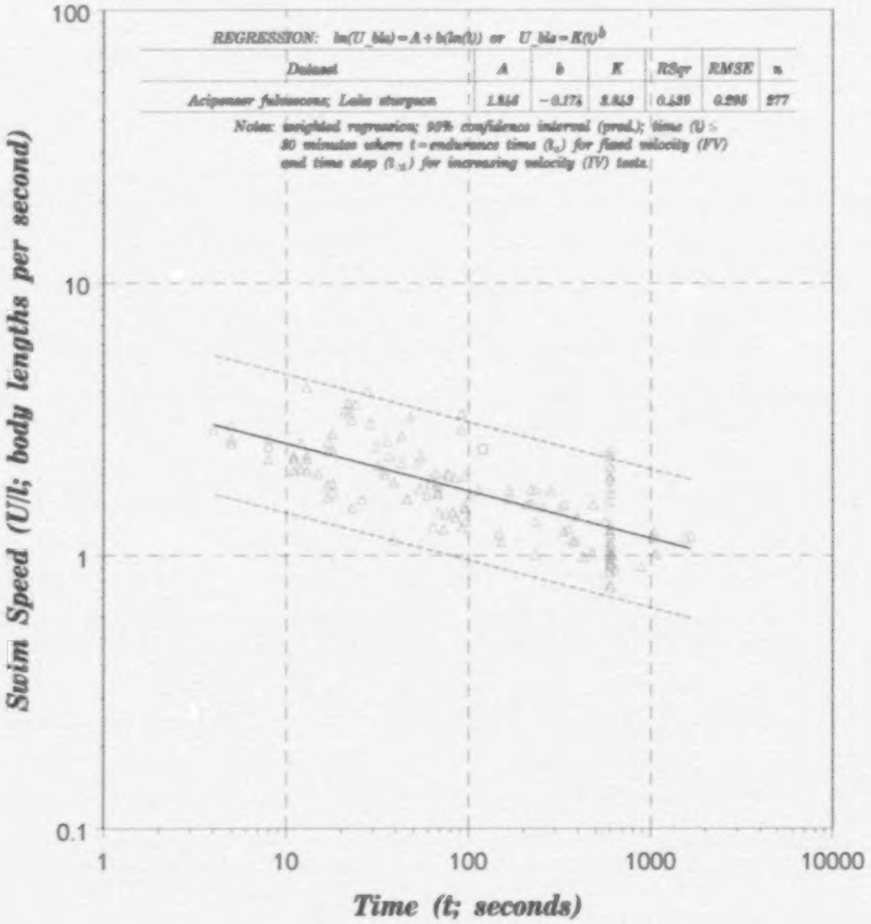


Figure B-003. Processed data for Acipenser fulvescens *(Lake Sturgeon): time-to-fatigueversus swim speed (body lengths per second). Blue square is data from Webb (1986); red triangles are data from Peake et al. (1995).*

Table B-003. Data summary. Fish count 277, record count 132

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.372	0.236	0.12	1.32	1.2	64
T (C)	13.4	4.9	7	21	14	4
U (m/s)	0.592	0.283	0.258	1.8	1.542	40
t_e (s)	154	264	4	1662	1658	78
$t_{\Delta t}$ (s)	538	162	120	600	480	2

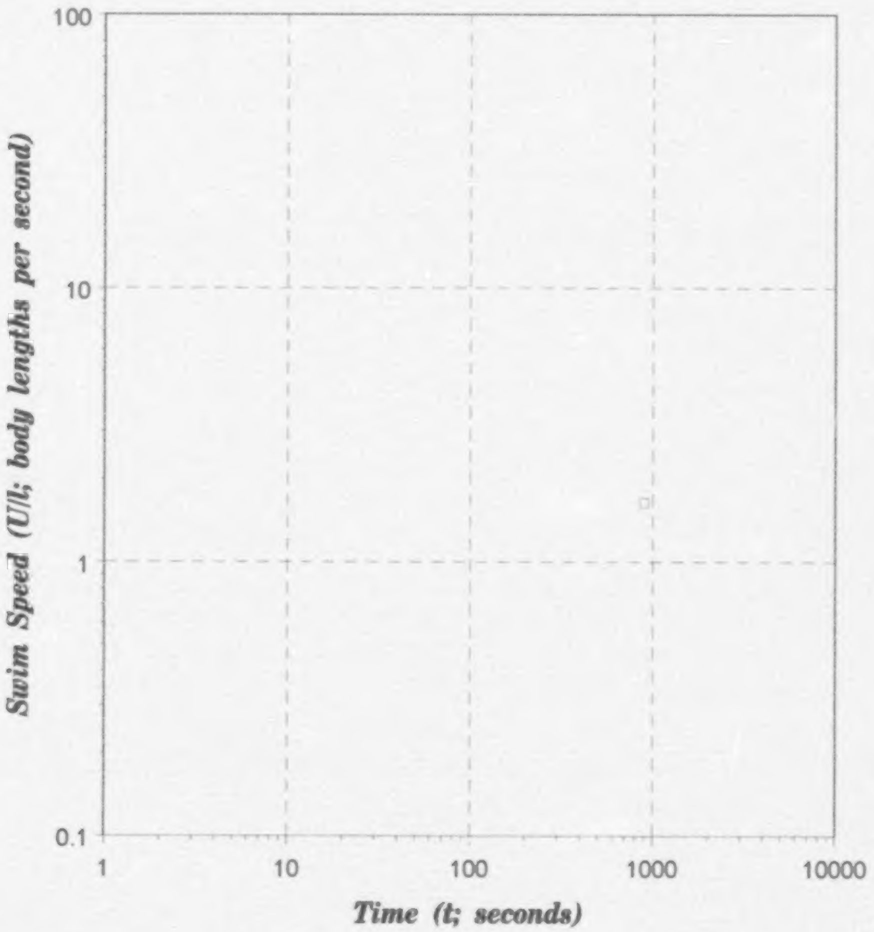


Figure B-004. Processed data for Acipenser transmontanus*; (White Sturgeon): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Counihan and Frost (1999).*

Table B-004. Data summary. Fish count 14, record count

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.342	0	0.342	0.342	0	1
T (C)	12	0	12	12	0	1
U (m/s)	0.564	0	0.564	0.564	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	900	0	900	900	0	1

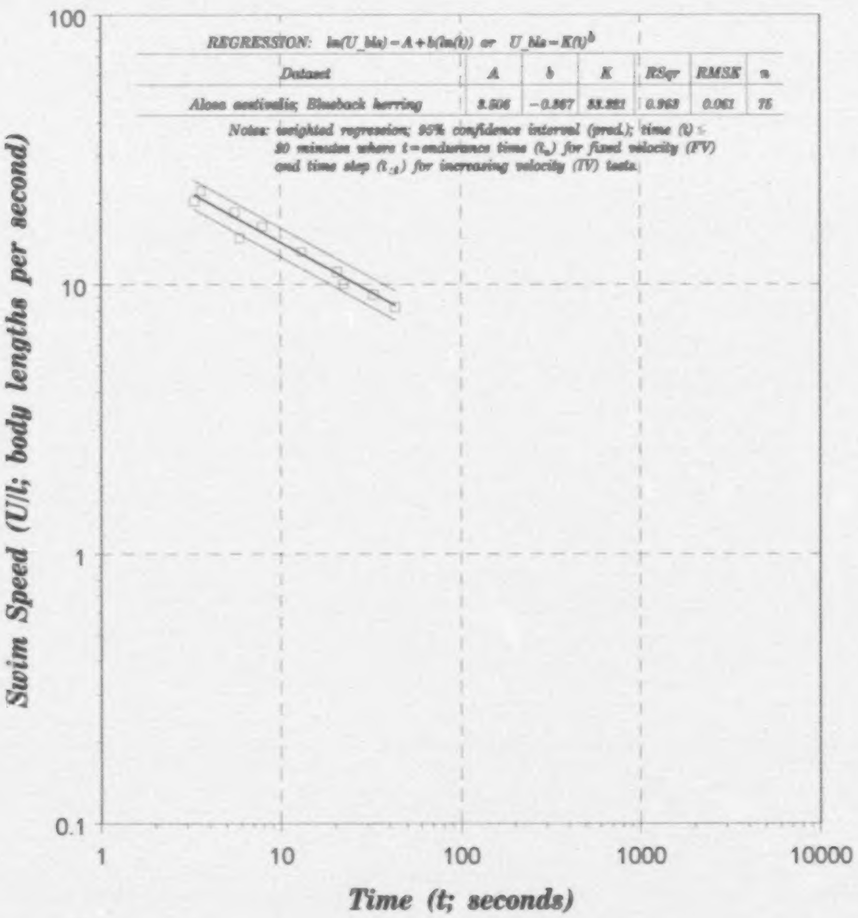


Figure B-005. Processed data for Alosa aestivalis; *(Blueback Herring): endurance time versus swim speed (body lengths per second). Blue squares are data from Castro-Santos (2005).*

Table B-005. Data summary. Fish count 75, record count 10.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.219	0	0.219	0.219	0	3
T (C)	16.9	0	16.9	16.9	0	1
U (m/s)	3.548	0.971	1.799	4.87	3.071	10
t_e (s)	12	13	3	43	40	10
$t_{\Delta t}$ (s)	.	.	.	.	.	0

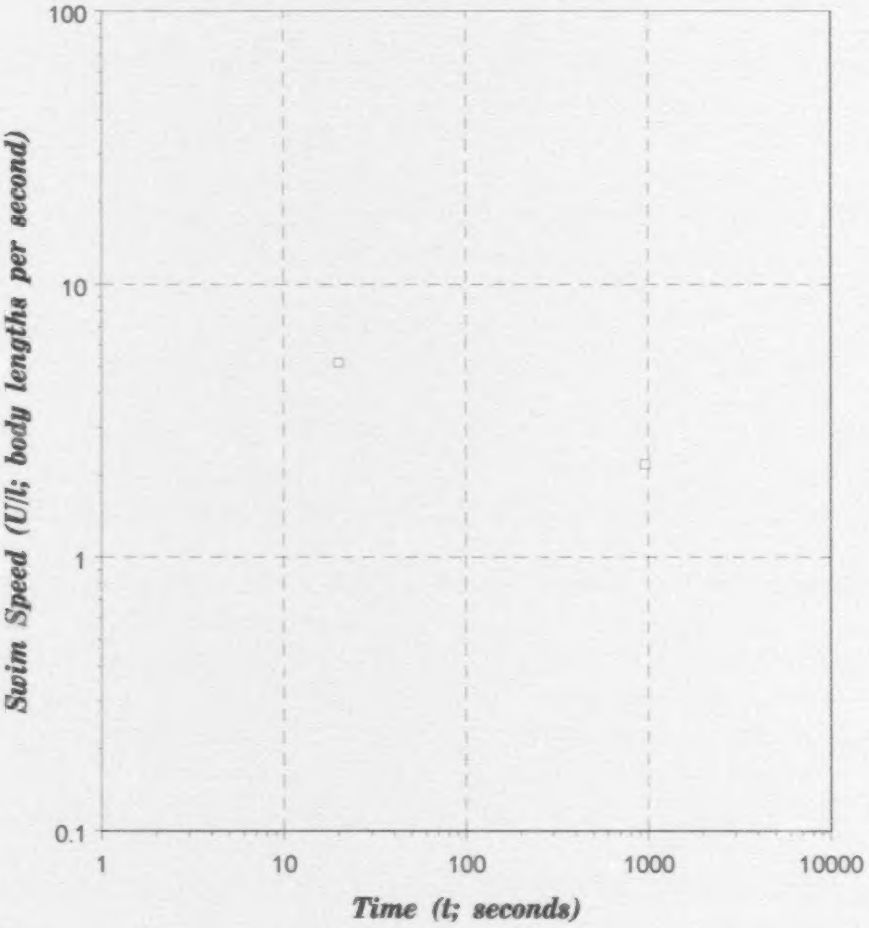


Figure B-006. Processed data for Alosa fallax; *(Twaite Shad): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Clough et al. (2004).*

Table B-006. Data summary. Fish count 19, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.335	0.004	0.333	0.341	0.008	2
T (C)	18.9	2.6	14.6	20.4	5.8	2
U (m/s)	1.465	0.439	0.75	1.721	0.971	2
t_e (s)	960	0	960	960	0	1
$t_{\Delta t}$ (s)	20	0	20	20	0	1

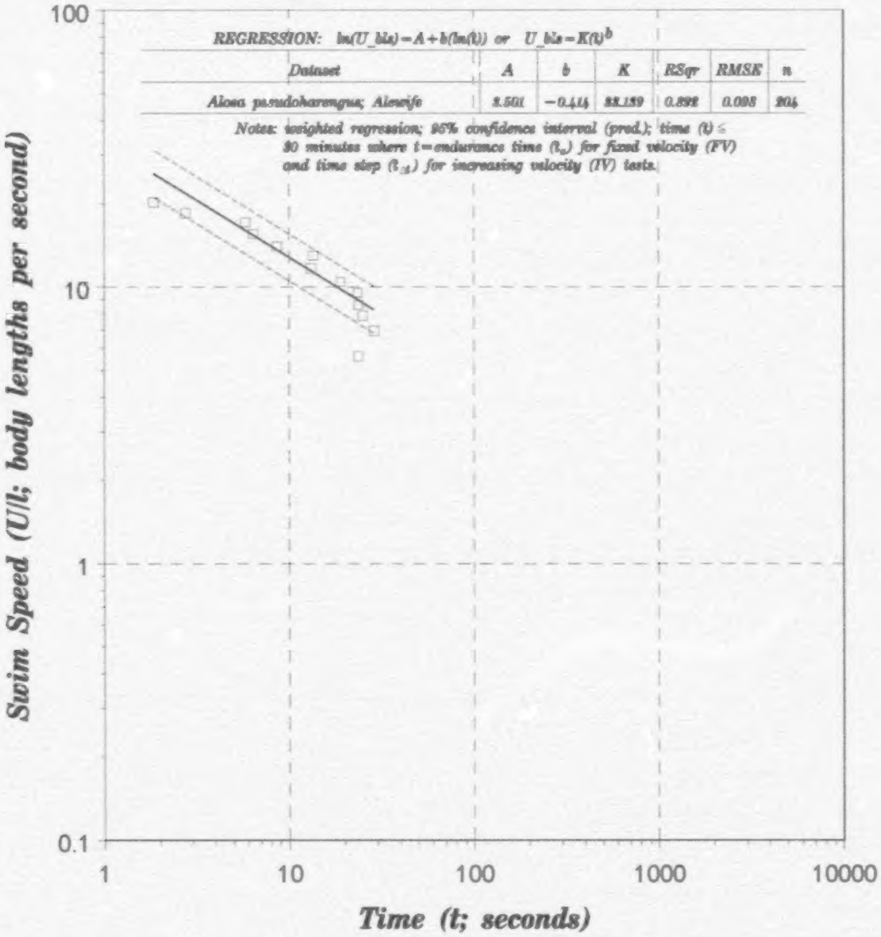
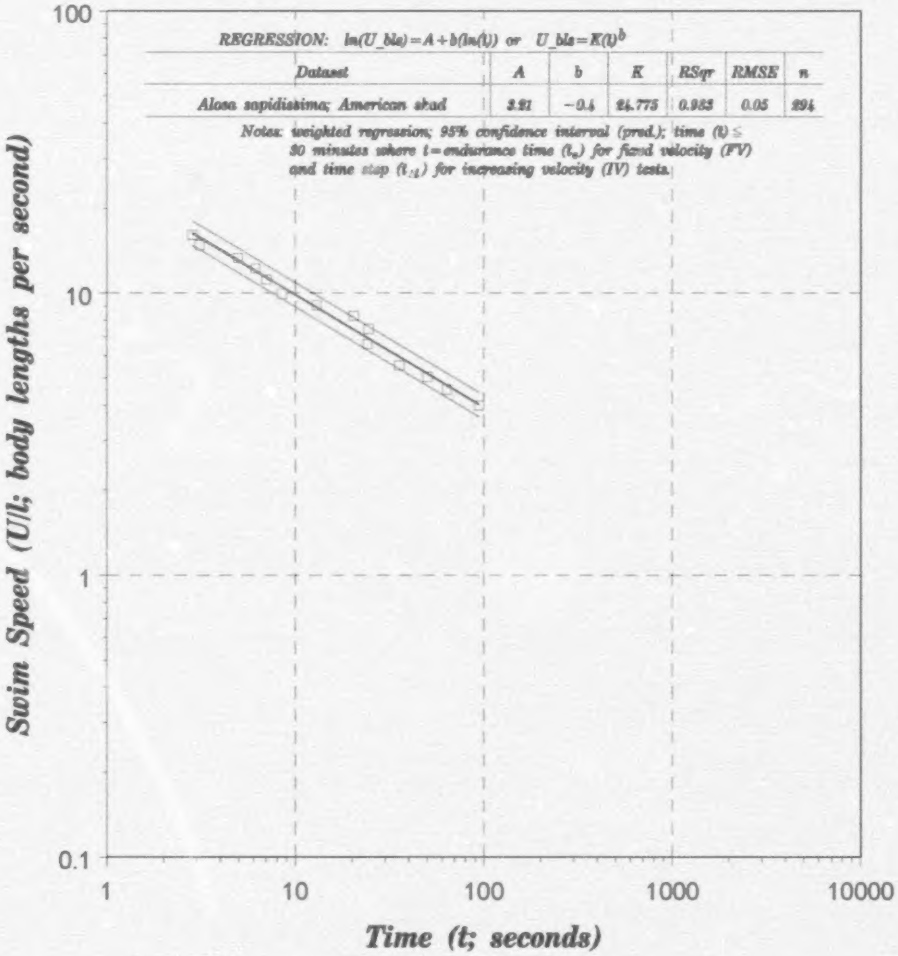


Figure B-007. Processed data for Alosa pseudoharengus *(Alewife): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Castro-Santos (2005).*

Table B-007. Data summary. Fish count 204, record count 13.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.237	0	0.237	0.237	0	3
T (C)	10.4	0	10.4	10.4	0	2
U (m/s)	2.89	0.835	1.33	4.795	3.465	1
t_e (s)	15	8	2	29	27	13
$t_{\Delta t}$ (s)	.	.	.	.	.	0



REGRESSION: $\ln(U\_bls) = A + b(\ln(t))$ or $U\_bls = K(t)^b$

Dataset	A	b	K	RSqr	RMSE	n
Alosa sapidissima; American shad	3.21	−0.4	24.775	0.983	0.05	294

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure B-008. Processed data for Alosa sapidissima *(American Shad): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Castro-Santos (2005).*

Table B-008. Data summary. Fish count 294, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.418	0	0.418	0.418	0	1
T (C)	18.3	0	18.3	18.3	0	1
U (m/s)	3.945	1.359	1.669	6.71	5.041	14
t_e (s)	21	22	3	94	91	14
$t_{\Delta t}$ (s)	.	.	.	.	.	0

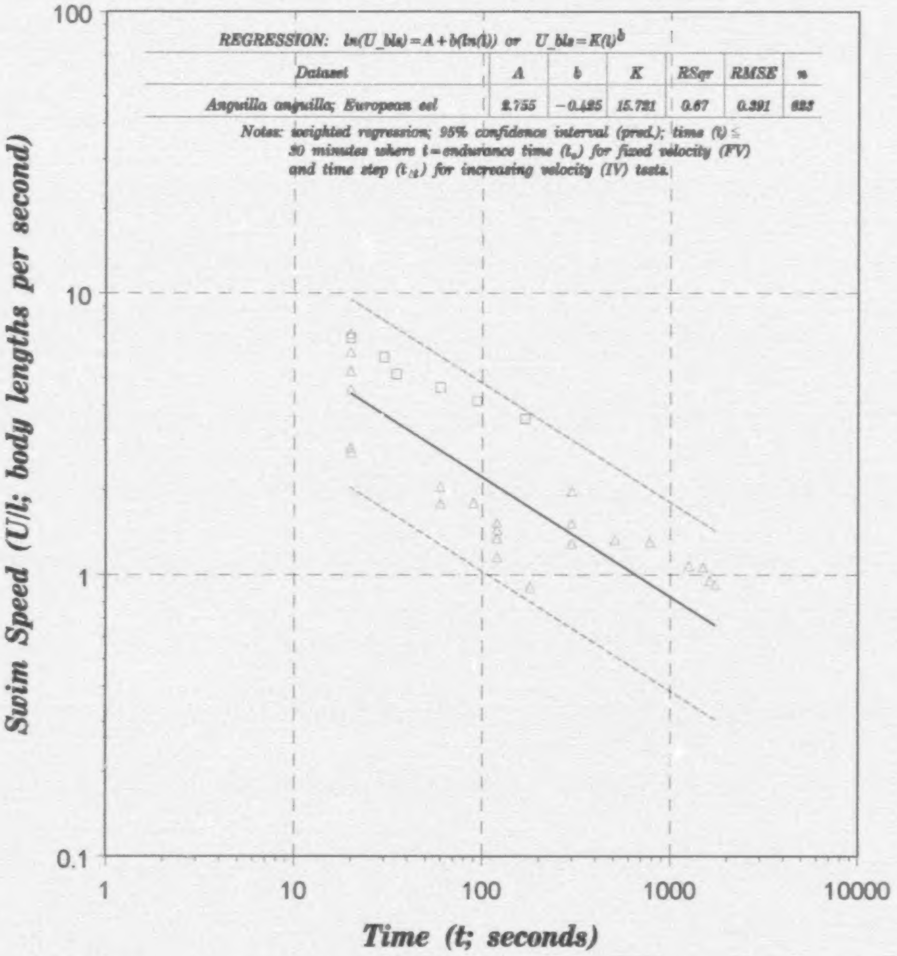


Figure B-009. Processed data for Anguilla anguilla *(European Eel): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from McCleeve (1980); red triangles are data from Clough et al. (2003).*

Table B-009. Data summary. Fish count 14, record count

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.26	0.143	0.072	0.57	0.498	24
T (C)	15.3	3.6	10.2	23.5	13.3	17
U (m/s)	0.759	0.442	0.205	1.284	1.079	22
t_e (s)	302	437	20	1740	1720	16
$t_{\Delta t}$ (s)	20	0	20	20	0	1

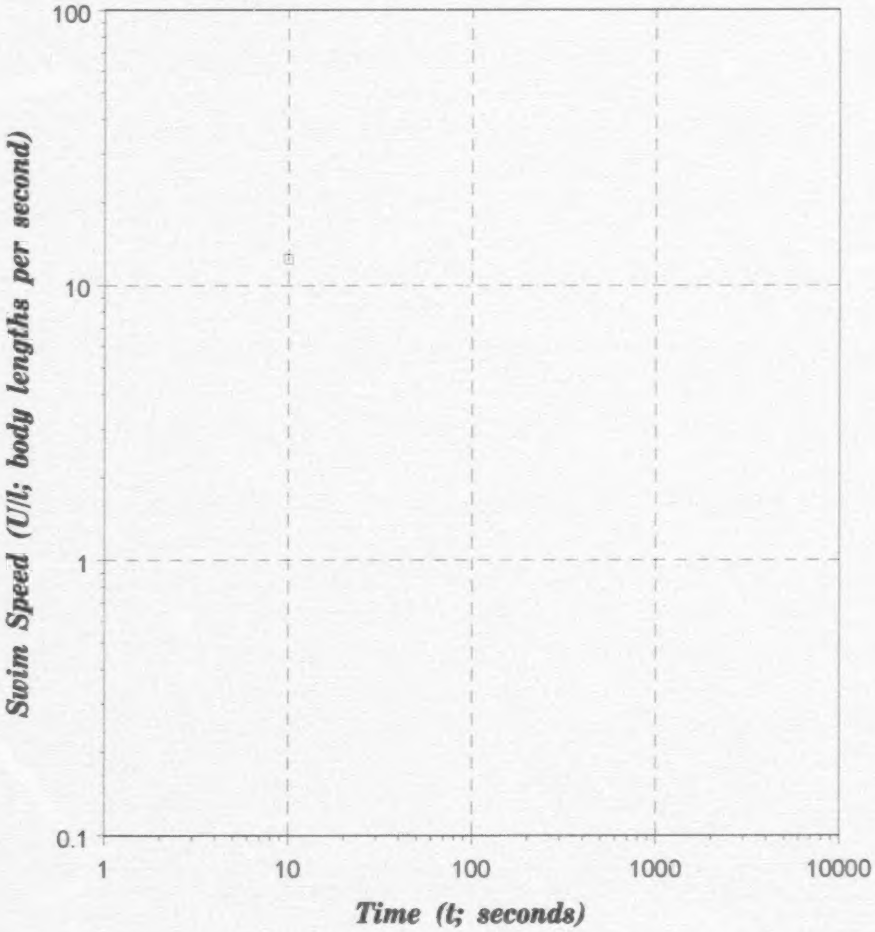


Figure B-010 Processed data for Astyanax mexicanus *(Mexican Tetra): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-010. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.041	0	0.041	0.041	0	1
T (C)	24.9	0	24.9	24.9	0	1
U (m/s)	0.509	0	0.509	0.509	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	10	1

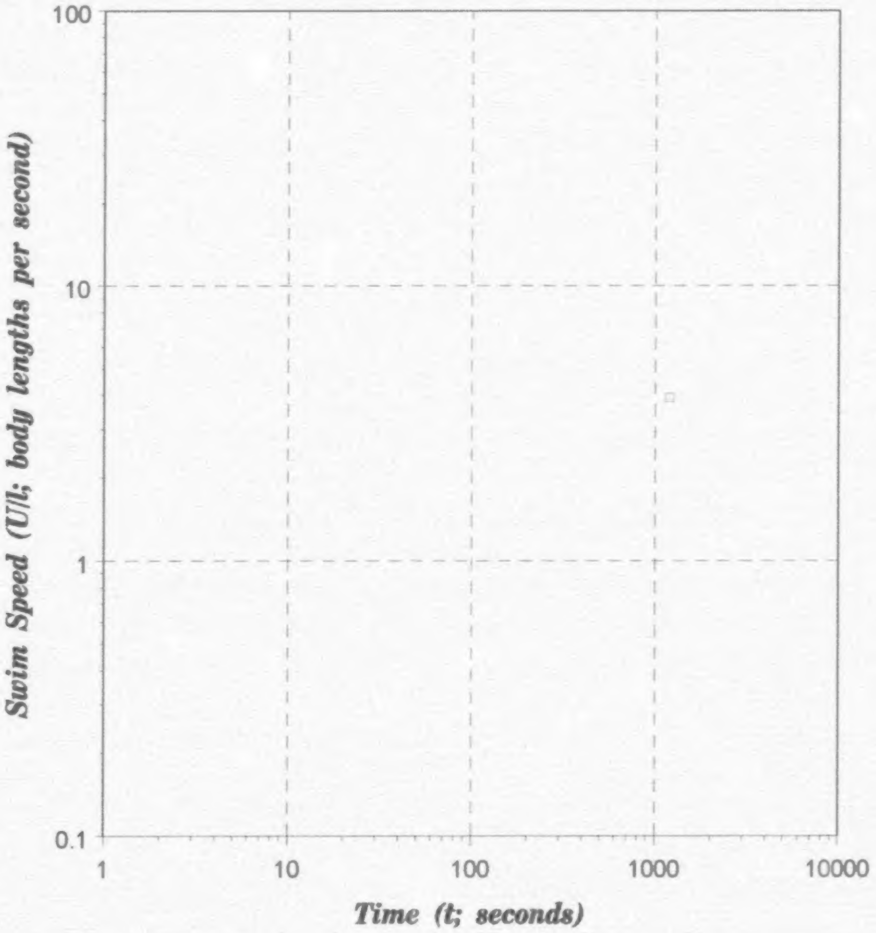


Figure B-011. Processed data for Barbatula barbatula *(Stone Loach): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Tudorache et al. (2008).*

Table B-011. Data summary. Fish count 8, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.072	0	0.072	0.072	0	1
T (C)	15	0	15	15	0	1
U (m/s)	0.283	0	0.283	0.283	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

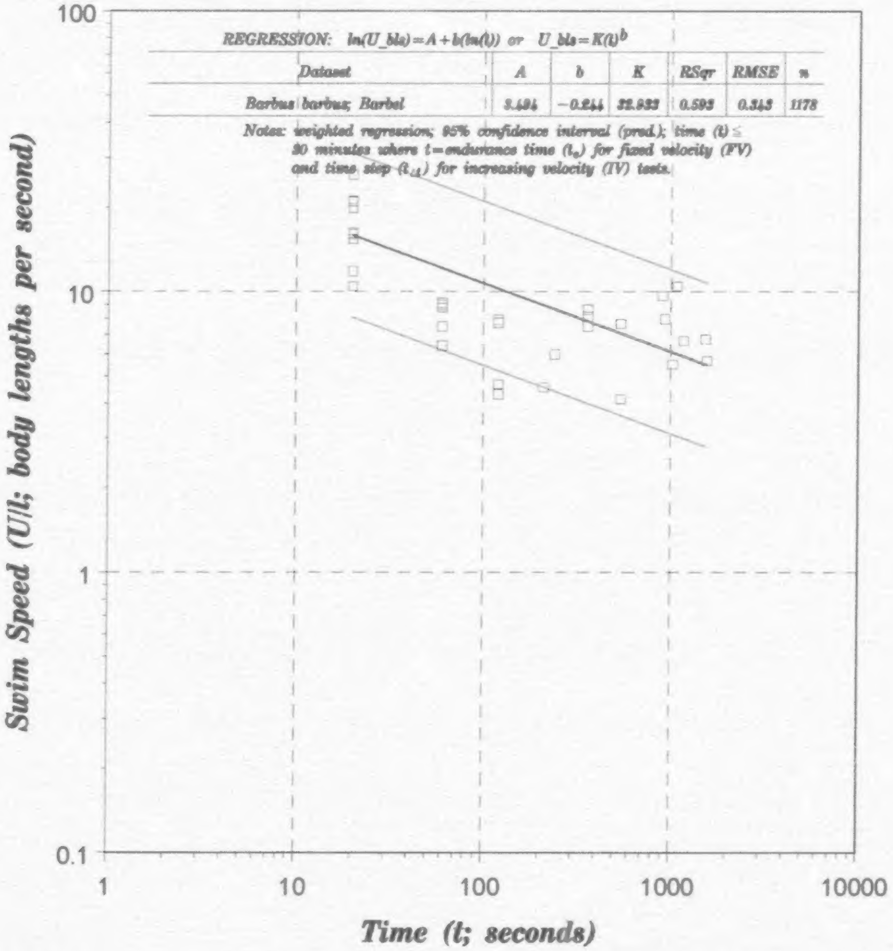


Figure B-012. Processed data for Barbus barbus *(*Barbel*): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Clough et al. (2003).*

Table B-012. Data summary. Fish count 14, record count

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.123	0.042	0.075	0.205	0.13	28
T (C)	13.1	4.1	7.3	22.9	15.6	24
U (m/s)	1.387	0.682	0.575	2.635	2.06	21
t_e (s)	636	504	60	1560	1500	13
$t_{\Delta t}$ (s)	20	0	20	20	0	1

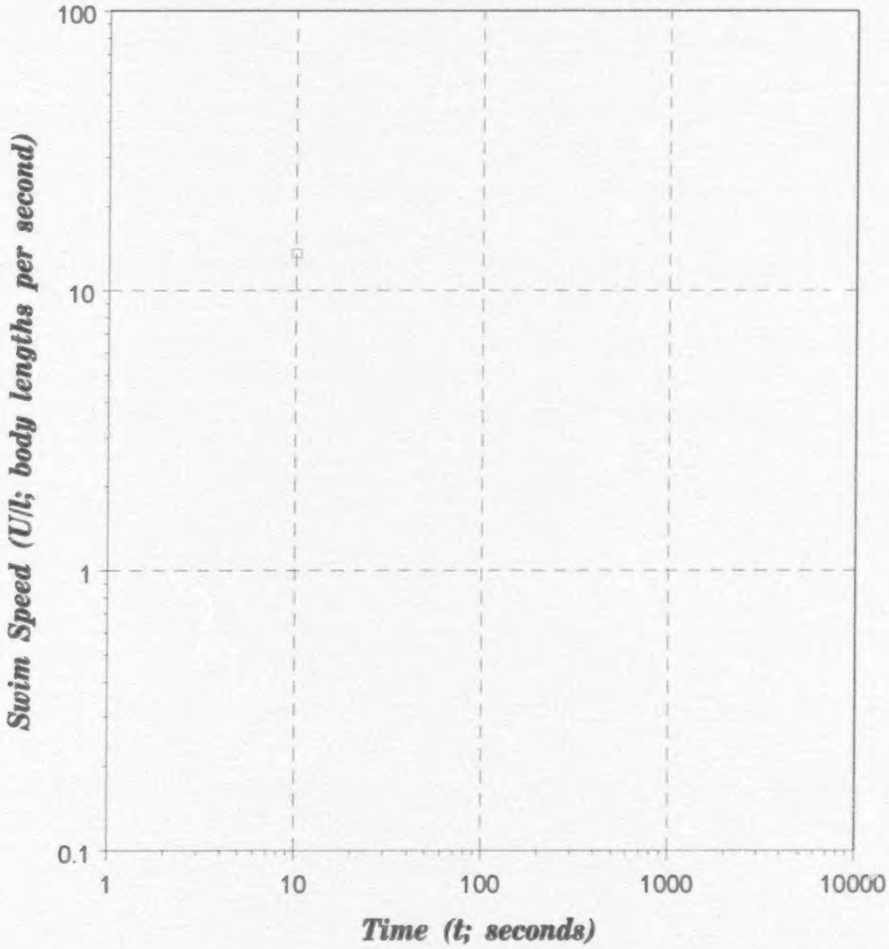


Figure B-013. Processed data for Campostoma anomalum *(Central Stoneroller): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-013. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.046	0	0.046	0.046	0	1
T (C)	28.2	0	28.2	28.2	0	1
U (m/s)	0.629	0	0.629	0.629	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

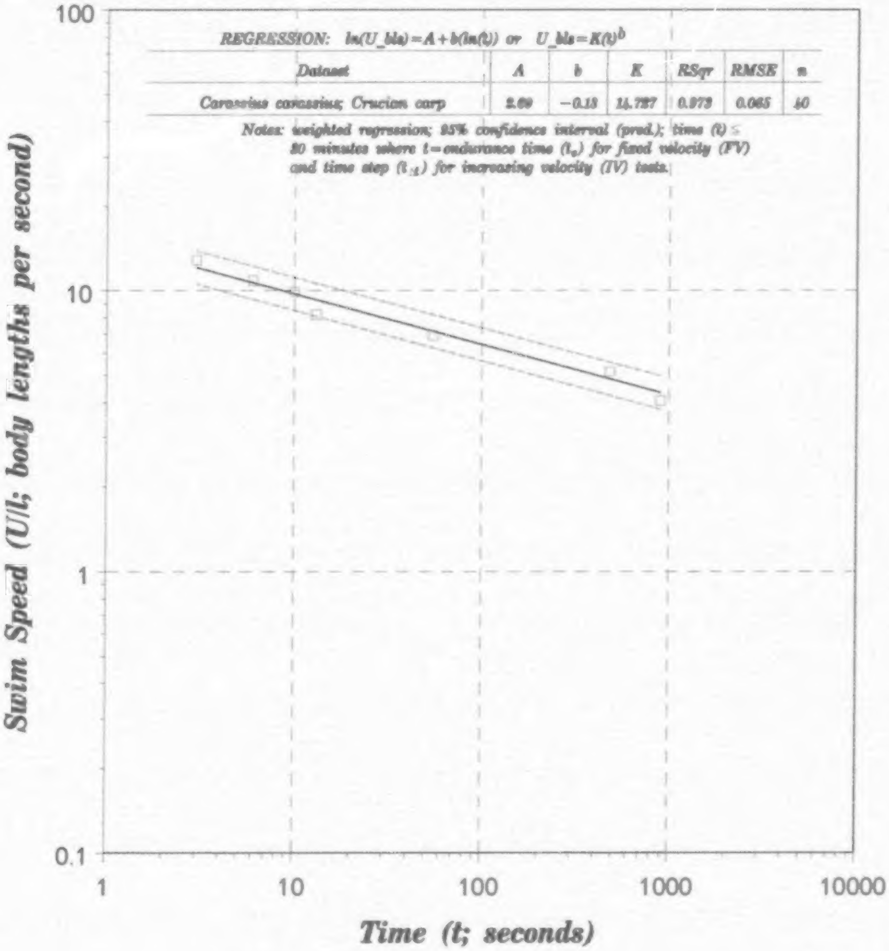


Figure B-014. Processed data for Carassius carassius *(Crucian Carp): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Tsukamoto et al. (1975).*

Table B-014. Data summary. Fish count 40, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.101	0	0.101	0.101	0	1
T (C)	13	0	13	13	0	1
U (m/s)	0.798	0.3	0.41	1.3	0.89	7
t_e (s)	245	321	3	900	897	7
$t_{\Delta t}$ (s)	.	.	.	.	.	0

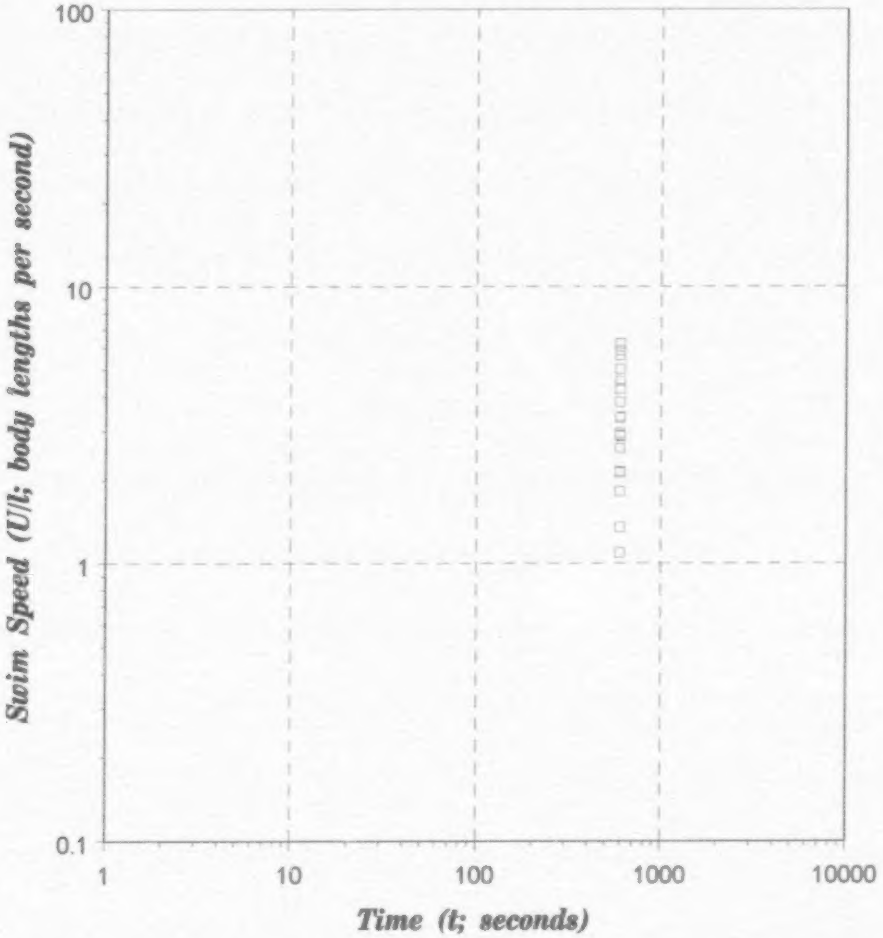


Figure B-015. Processed data for Catostomus catostomus *(Longnose Sucker): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973).*

Table B-015. Data summary. Fish count 150, record count 18.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.22	0.112	0.04	0.52	0.48	18
T (C)	13.5	0	13.5	13.5	0	1
U (m/s)	0.568	0.154	0.182	0.78	0.598	18
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

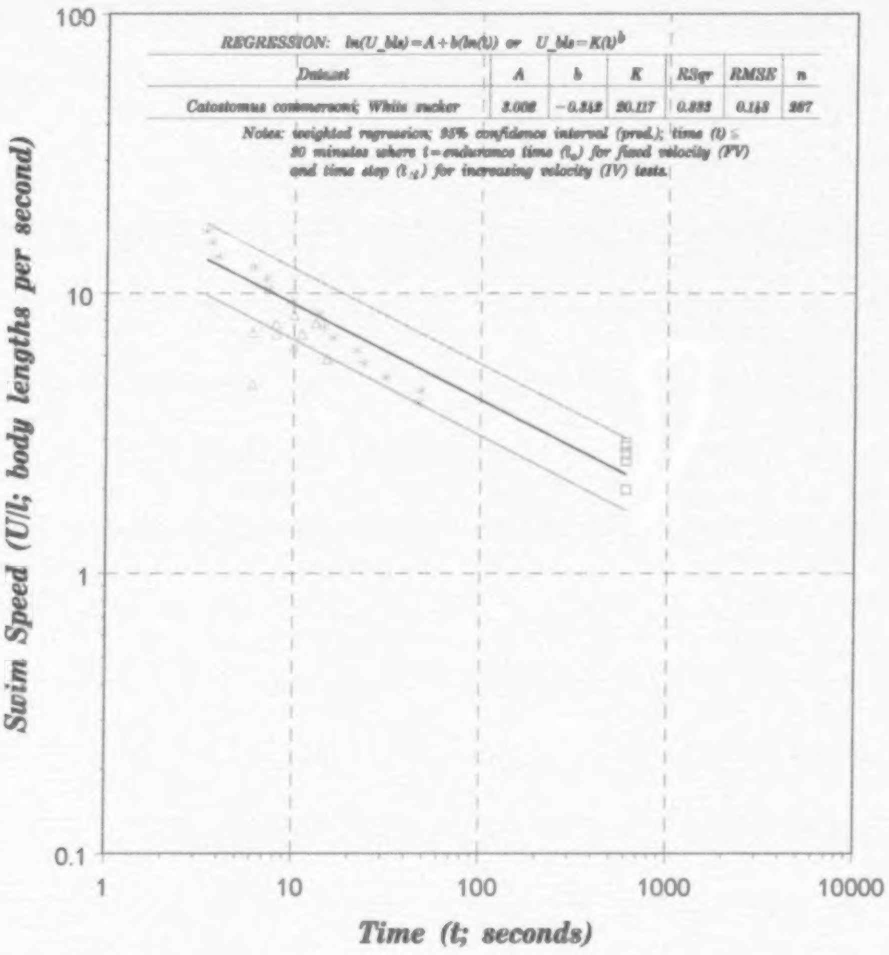


Figure B-016. Processed data for Catostomus commersoni *(White Sucker): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973); red triangles are data from McAuley (1996); green stars are data from Castro-Santos (2005).*

Table B-106. Data summary. Fish count 287 record count 29

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.383	0.051	0.165	0.5	0.335	14
T (C)	14.2	1.5	10.5	16	5.5	3
U (m/s)	3.612	1.325	0.483	6.587	6.104	29
t_e (s)	11	8	3	48	45	21
$t_{\Delta t}$ (s)	600	0	600	600	0	1

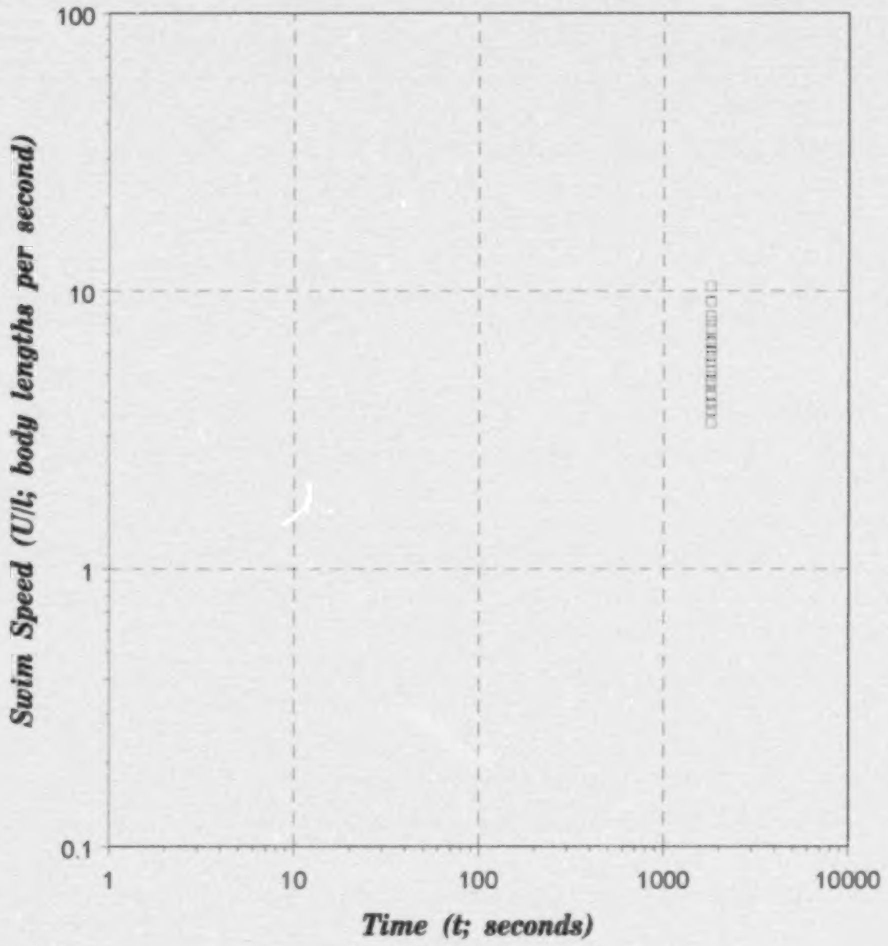


Figure B-017. Processed data for Catostomus laipinnis *(Flannelmouth Sucker): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Ward et al. (2002).*

Table B-017. Data summary. Fish count: 588, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.064	0.026	0.024	0.114	0.09	285
T (C)	14.6	4.1	10	20	10	3
U (m/s)	0.351	0.118	0.157	0.663	0.506	25
t_e (s)	1800	0	1800	1800	0	1
$t_{\Delta t}$ (s)	.	.	.	.	.	0

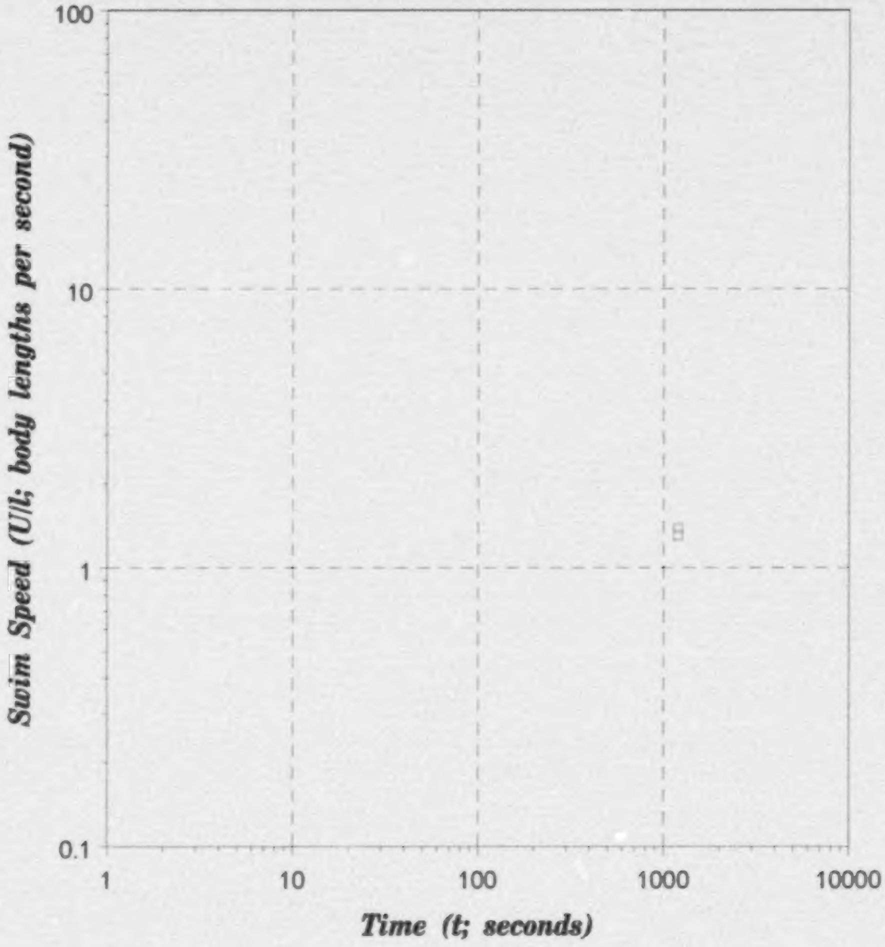


Figure B-018. Processed data for Catostomus macrochellus *(Largescale Sucker): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Kolok et al. (1993).*

Table B-018. Data summary. Fish count 24, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.397	0	0.397	0.397	0	1
T (C)	13	3.1	10	16	6	2
U (m/s)	0.535	0.015	0.52	0.55	0.03	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

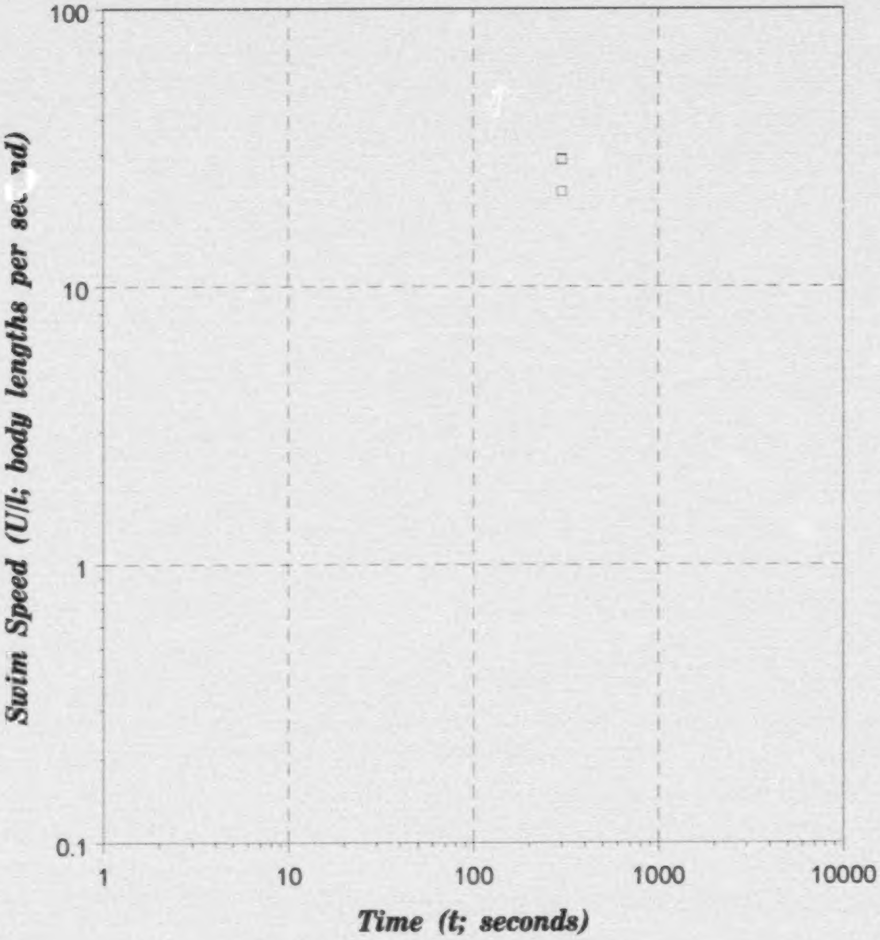


Figure B-019. Processed data for Catostomus platyrhynchus *(Mountain Sucker): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Aedo et al. (2009).*

Table B-019. Data summary. Fish count 14, record count 3.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.025	0.002	0.023	0.029	0.006	3
T (C)	17	0	17	17	0	1
U (m/s)	0.641	0.141	0.507	0.832	0.325	3
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

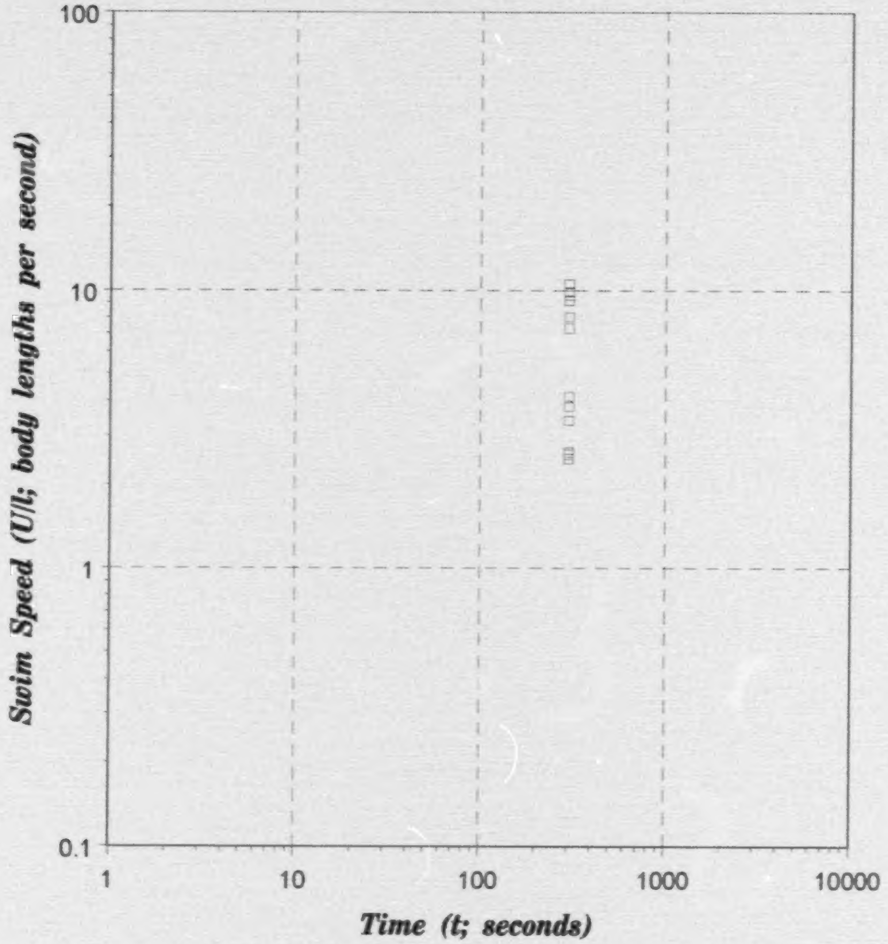


Figure B-020. Processed data for Chasmistes liorus *(June Sucker): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Aedo et al. (2009).*

Table B-020. Data summary. Fish count 26, record count 12.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.1	0.061	0.028	0.205	0.177	12
T (C)	17	0	17	17	0	1
U (m/s)	0.42	0.076	0.289	0.536	0.247	12
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

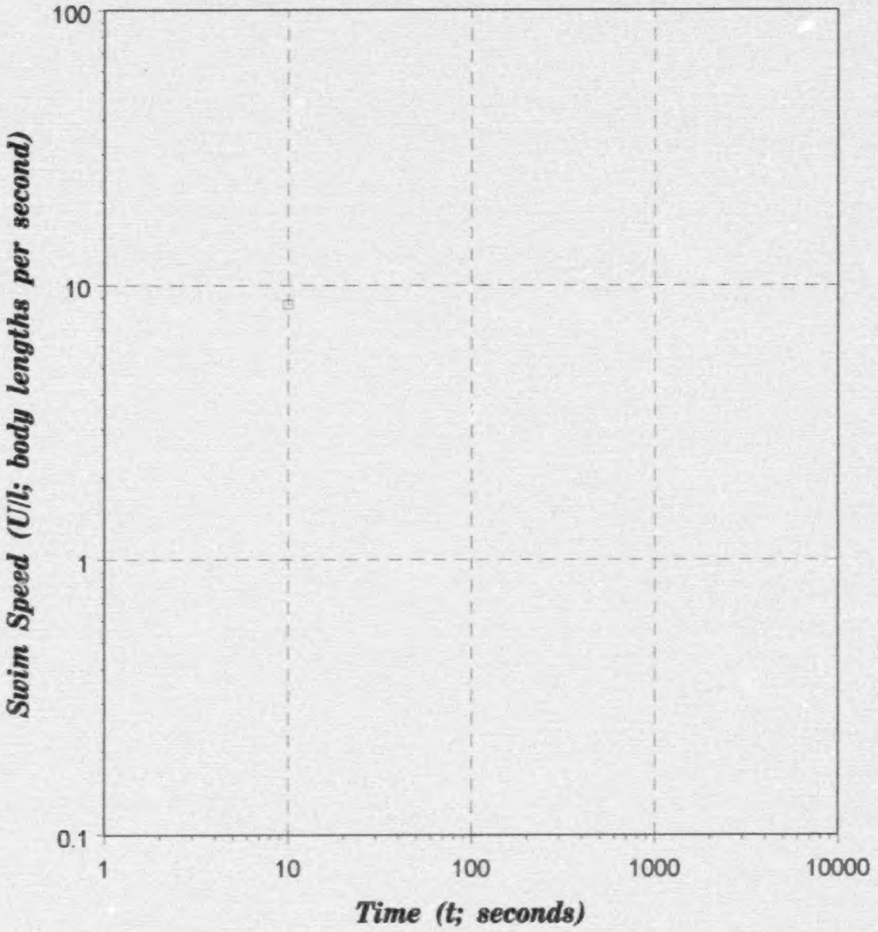


Figure B-021. Processed data for Cichlasoma cyanoguttatum *(Rio Grande Cichlid): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-021. Data summary. Fish count 8, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.039	0	0.039	0.039	0	1
T (C)	25.6	0	25.6	25.6	0	1
U (m/s)	0.33	0	0.33	0.33	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

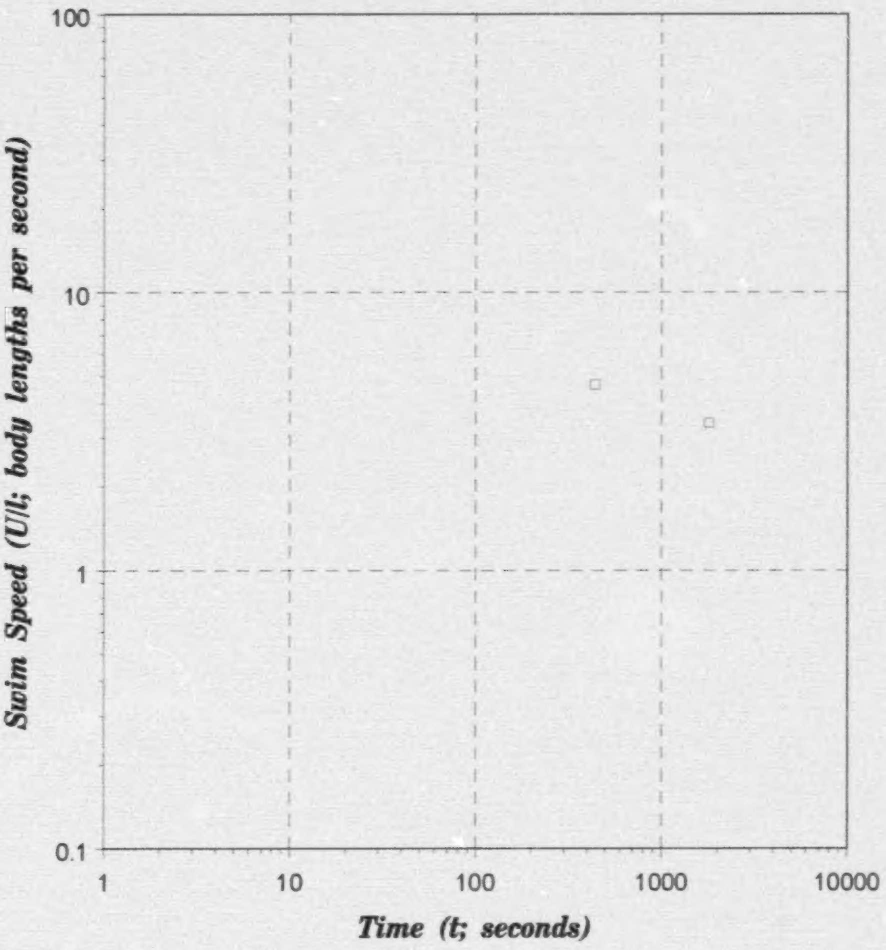


Figure B-022. Processed data for Coregonus artedii *(Cisco): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Bernatchez and Dodson (1985).*

Table B-022. Data summary. Fish count 28, record count 2

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.135	0	0.135	0.135	0	1
T (C)	12	0	12	12	0	1
U (m/s)	0.581	0.079	0.458	0.63	0.172	2
t_e (s)	438	0	438	438	0	1
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

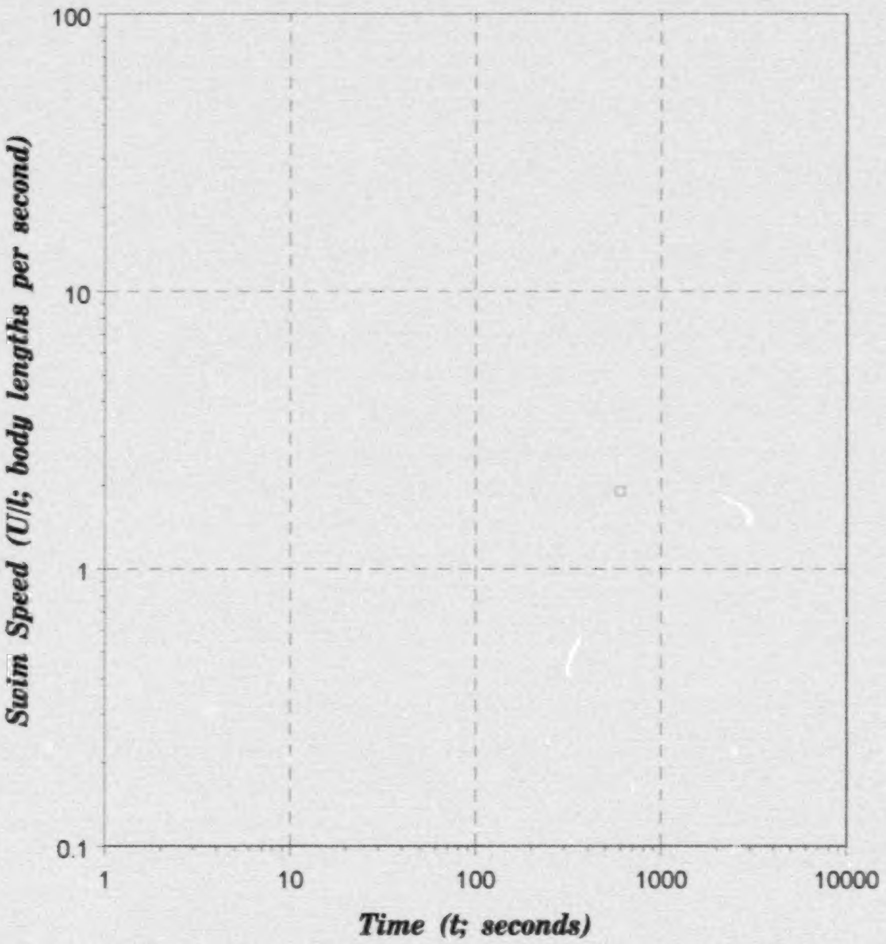
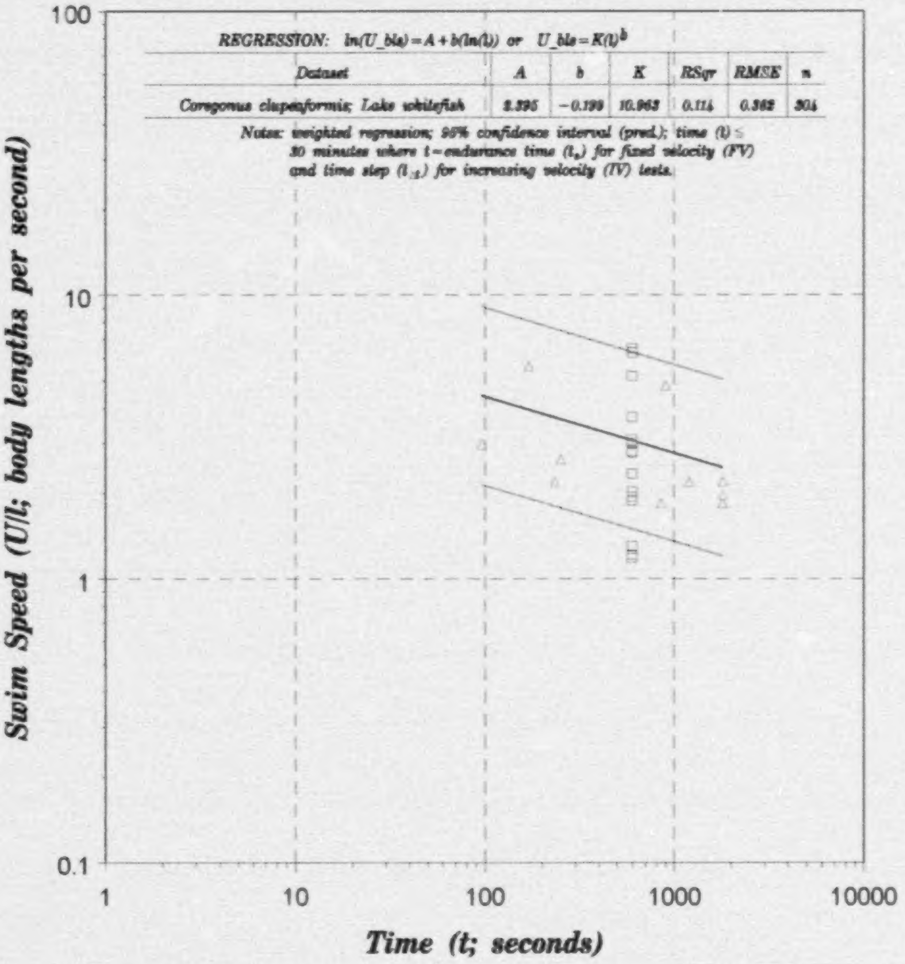


Figure B-023. Processed data for Coregonus autumnalis *(Arctic Cisco): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Jones et al. (1973).*

Table B-023. Data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.42	0	0.42	0.42	0	1
T (C)	10	0	10	10	0	1
U (m/s)	0.8	0	0.8	0.8	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1



REGRESSION: $\ln(U\_bls) = A + b(\ln(t))$ or $U\_bls = K(t)^b$

Dataset	A	b	K	RSqr	RMSE	n
Coregonus clupeaformis; Lake whitefish	2.395	−0.199	10.963	0.114	0.362	304

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure B-024. Processed data for Coregonus clupeaformis *(Lake Whitefish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973); red triangles are data from Bernatchez and Dodson (1985).*

Table B-024. Data summary. Fish count 304, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.216	0.096	0.07	0.52	0.45	18
T (C)	12.3	2.5	5	17	12	4
U (m/s)	0.619	0.13	0.26	1.02	0.76	22
t_e (s)	579	390	96	1200	1104	7
$t_{\Delta t}$ (s)	771	420	600	1800	1200	2

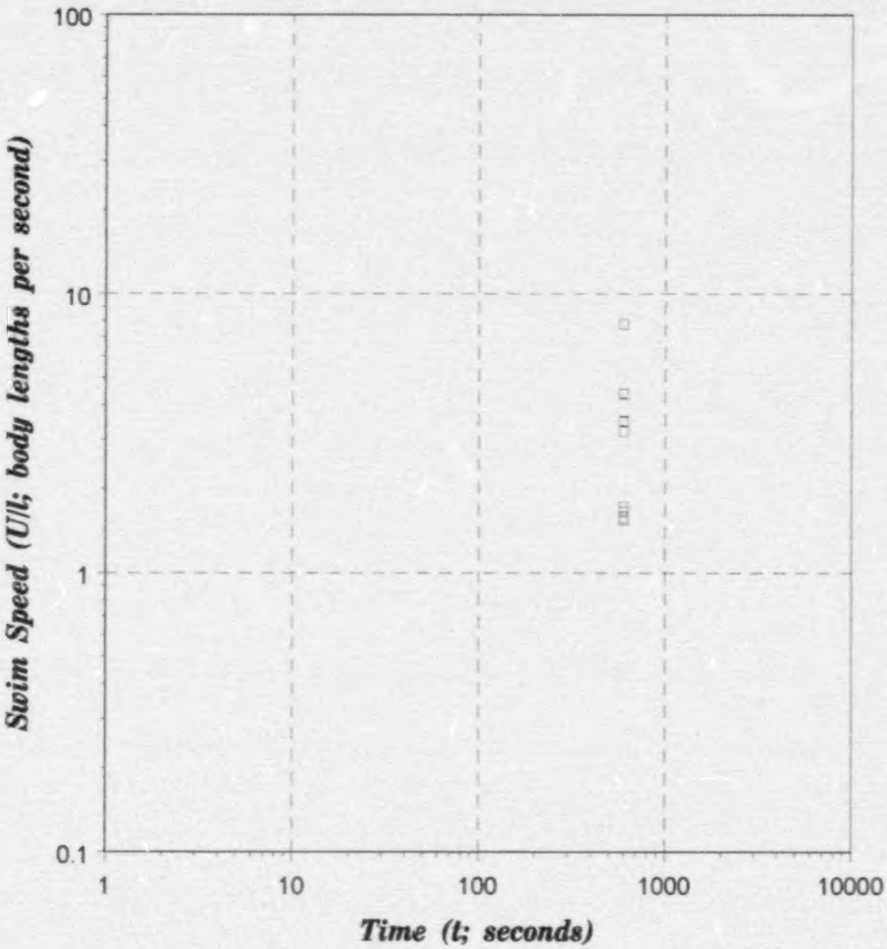


Figure B-025. Processed data for Coregonus nasus *(Broad Whitefish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973).*

Table B-025. Data summary. Fish count 21, record count 10.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.206	0.096	0.05	0.33	0.28	10
T (C)	12.5	0	12.5	12.5	0	1
U (m/s)	0.437	0.086	0.21	0.66	0.45	10
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

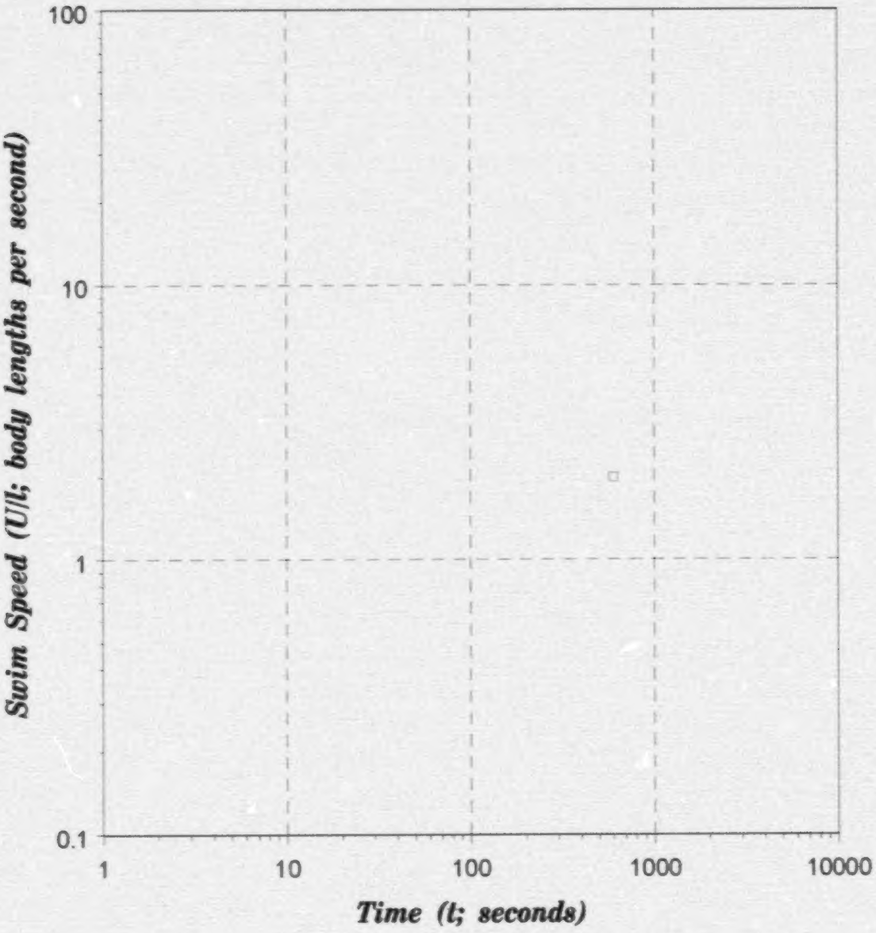


Figure B-026. Processed data for Coregonus sardinella (Least Cisco)*: time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Jones et al. (1973).*

Table B-026. Data summary. Fish count 2, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0	0.3	0.3	0	1
T (C)	16	0	16	16	0	1
U (m/s)	0.6	0	0.6	0.6	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

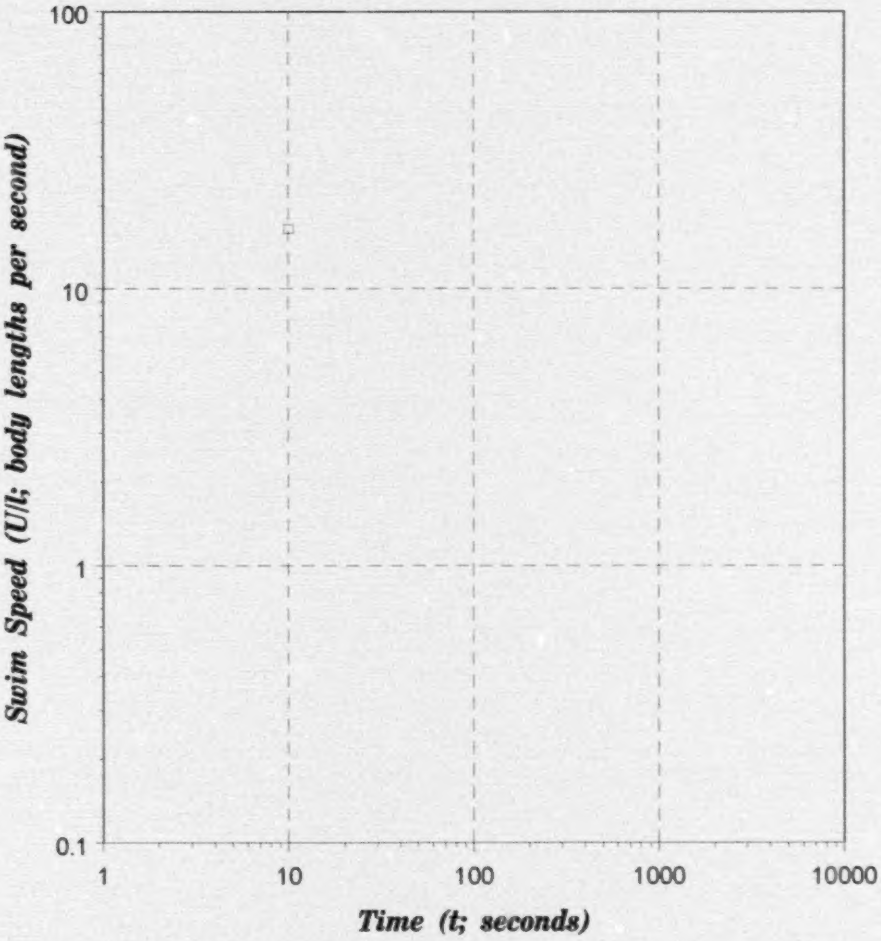


Figure B-027. Processed data for Cyprinella lutrensis *(Red Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-027. Data summary. Fish count 16, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	27.7	0	27.7	27.7	0	1
U (m/s)	0.712	0	0.712	0.712	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

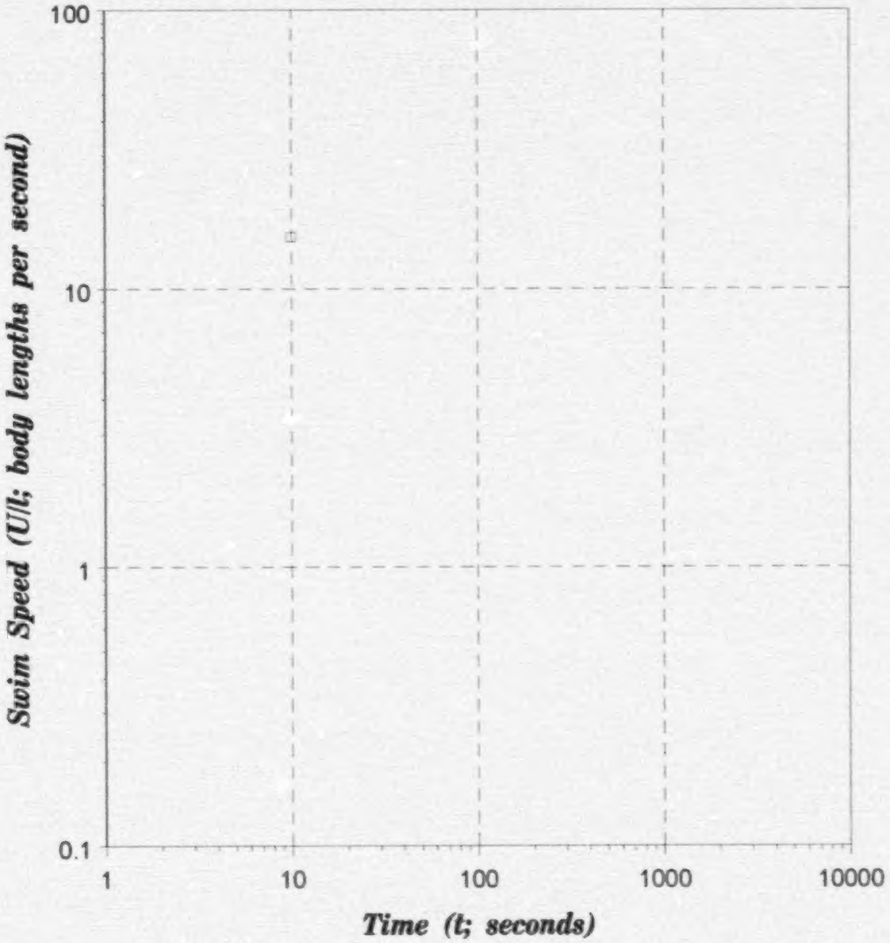


Figure B-028. Processed data for Cyprinella proserpina *(Proserpine Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-028. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0	0.04	0.04	0	1
T (C)	23.5	0	23.5	23.5	0	1
U (m/s)	0.608	0	0.608	0.608	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

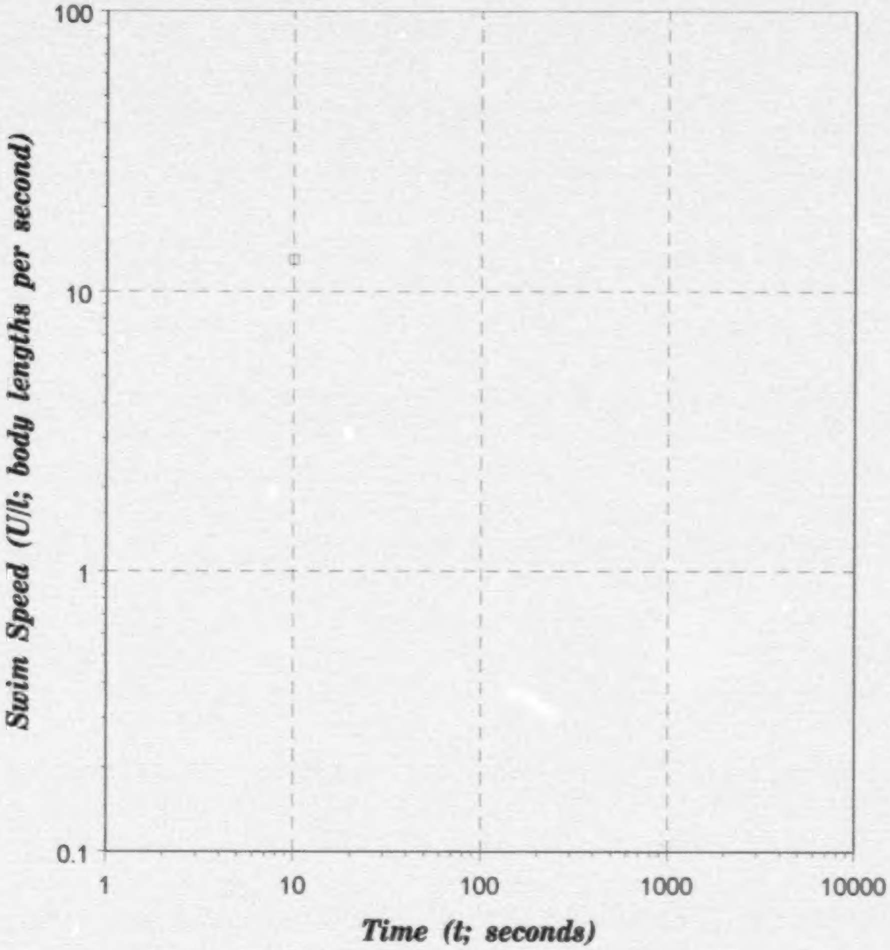


Figure B-029. Processed data for Cyprinella venusta *(Blacktail Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-029. Data summary. Fish count 19, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.047	0	0.047	0.47	0	1
T (C)	23.1	0	23.1	23.1	0	1
U (m/s)	0.611	0	0.611	0.611	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

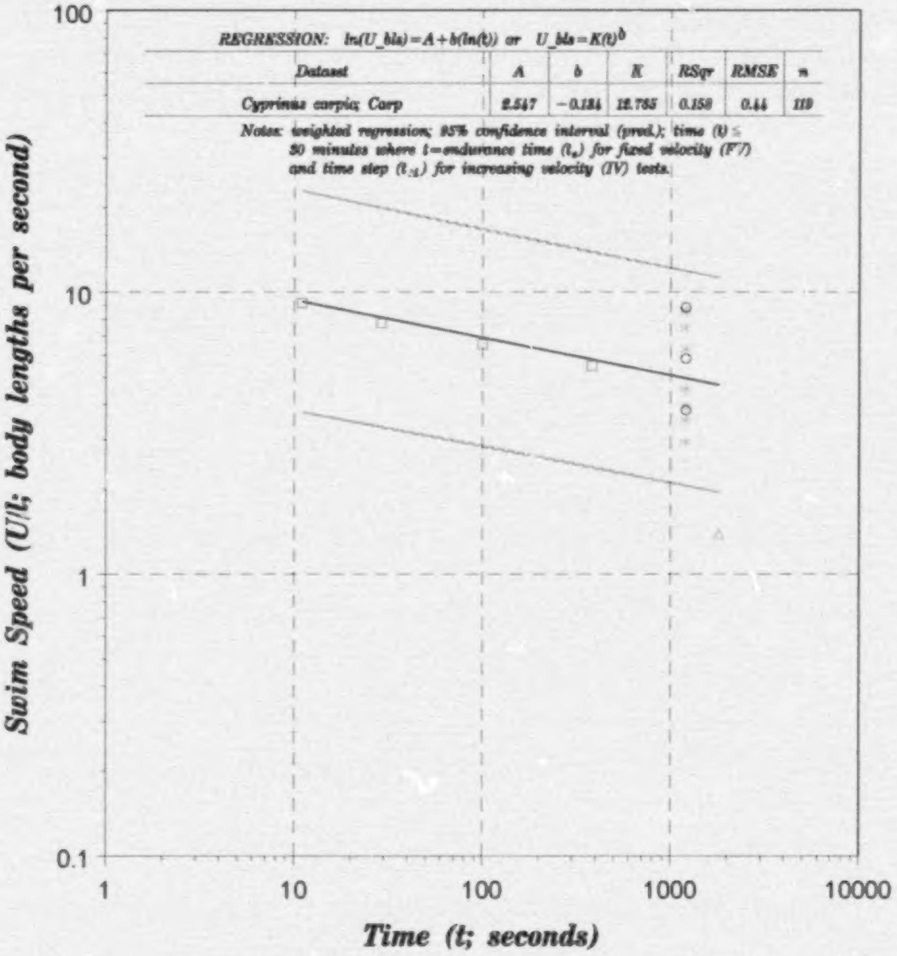


Figure B-030. Processed data for Cyprinus carpio *(Carp): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Tsukamoto et al. (1975); red triangles are data from West et al. (1994); green stars are data from Tudorache et al. (2007); black circles are data from Tudorache et al. (2008).*

Table B-030. Data summary. Fish count 119, record count 16.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.163	0.095	0.049	0.44	0.391	9
T (C)	18.6	3.8	11.5	22	10.5	3
U (m/s)	0.779	0.257	0.433	1.4	0.967	16
t_e (s)	110	141	11	380	369	4
$t_{\Delta t}$ (s)	1238	147	1200	1800	600	2

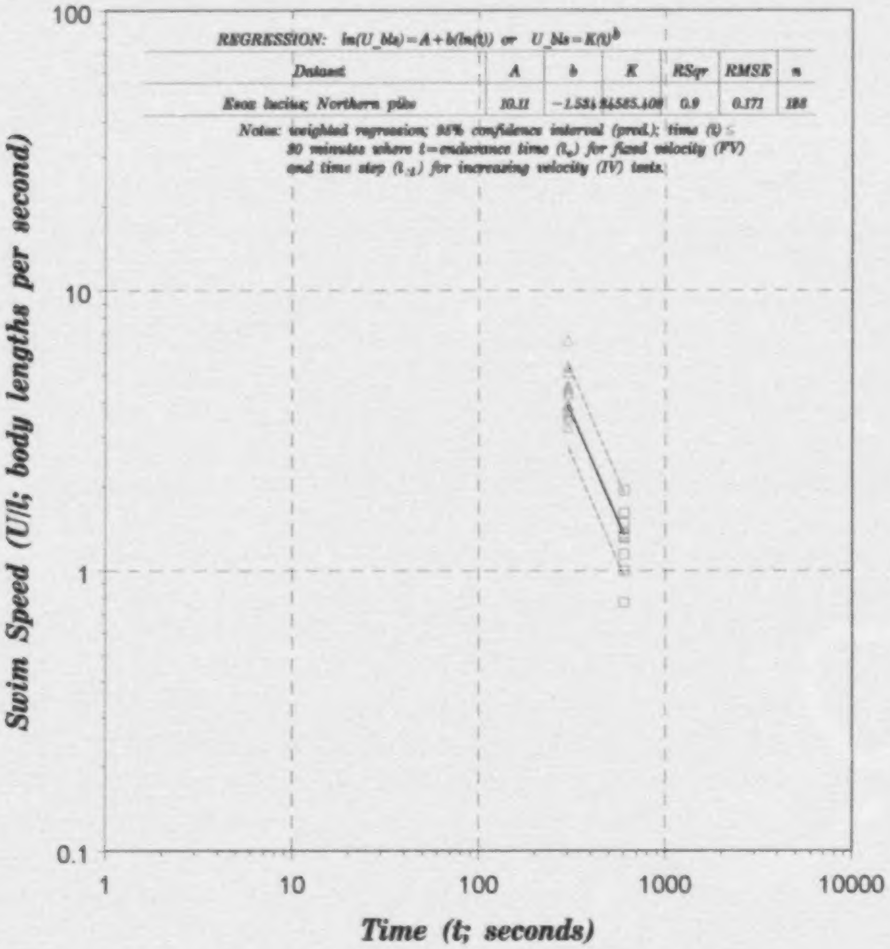


Figure B-031. Processed data for Esox lucius *(Northern Pike): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973); red triangles are data from Peake (2004b).*

Table B-031. Data summary. Fish count 128, record count 25.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.108	0.095	0.024	0.48	0.456	25
T (C)	16.5	3.4	12	19	7	2
U (m/s)	0.221	0.063	0.126	0.435	0.309	23
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	405	144	300	600	300	2

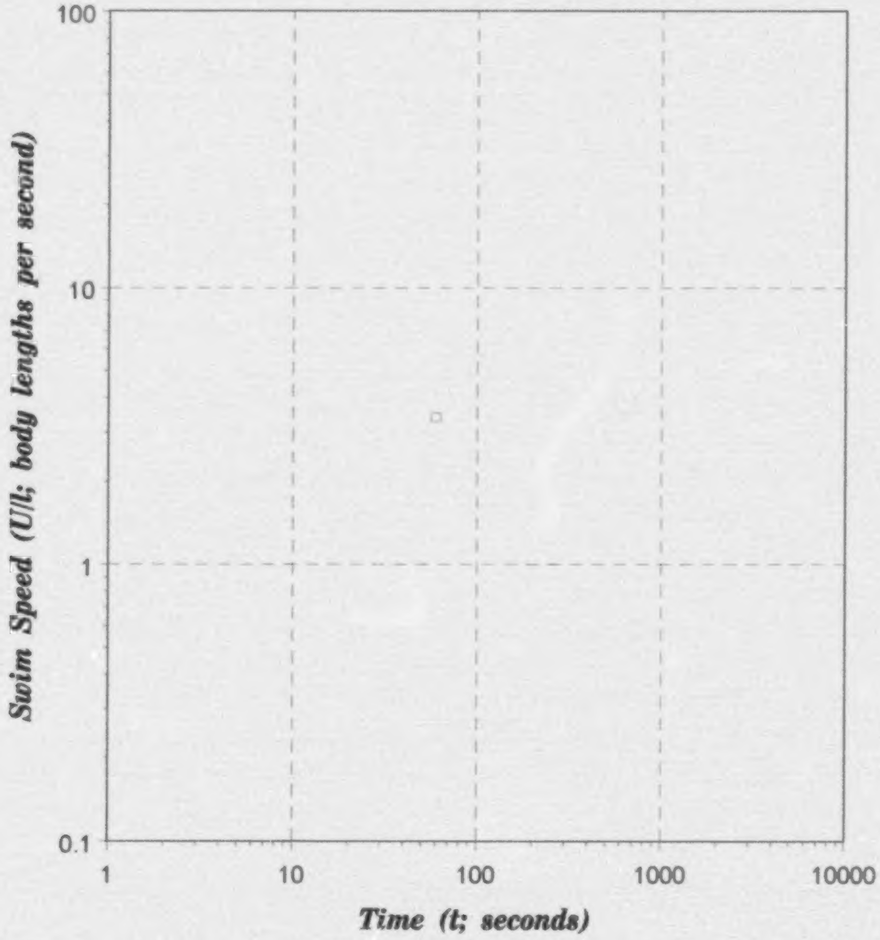


Figure B-032. Processed data for Esox sp. *(Tiger Muskellunge): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Webb et al. (1992).*

Table B-032. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.189	0	0.189	0.189	0	1
T (C)	25	0	25	25	0	1
U (m/s)	0.642	0	0.642	0.642	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	60	0	60	60	0	1

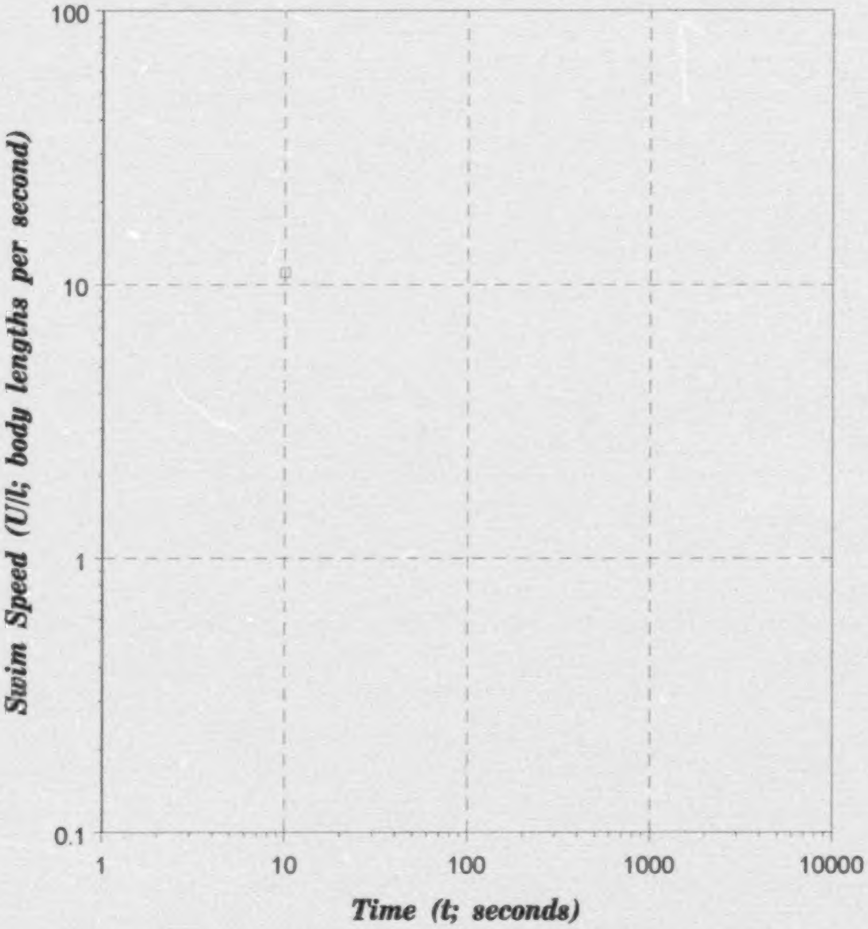


Figure B-033. Processed data for Etheostoma grahami *(Rio Grande Darter): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-033. Data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	24.1	0	24.1	24.1	0	1
U (m/s)	0.4	0	0.4	0.4	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

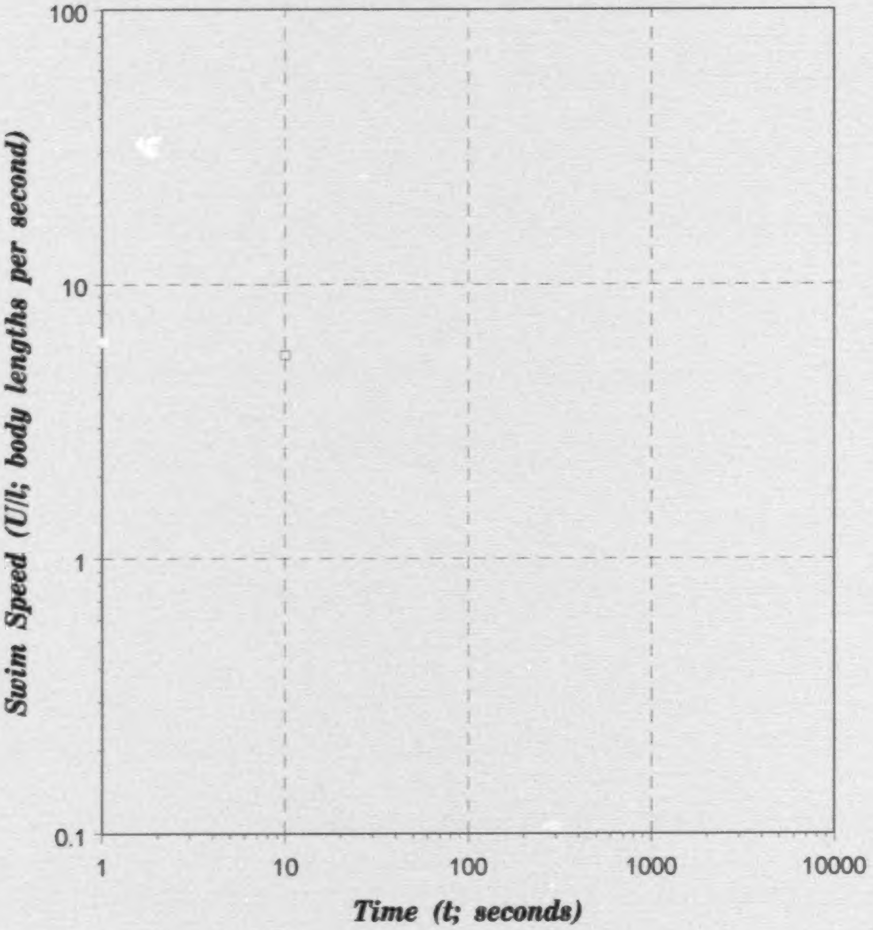


Figure B-034. Processed data for Fundulus notatus *(Blackstripe Topminnow): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-034. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.056	0	0.056	0.056	0	1
T (C)	28.3	0	28.3	28.3	0	1
U (m/s)	0.307	0	0.307	0.307	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

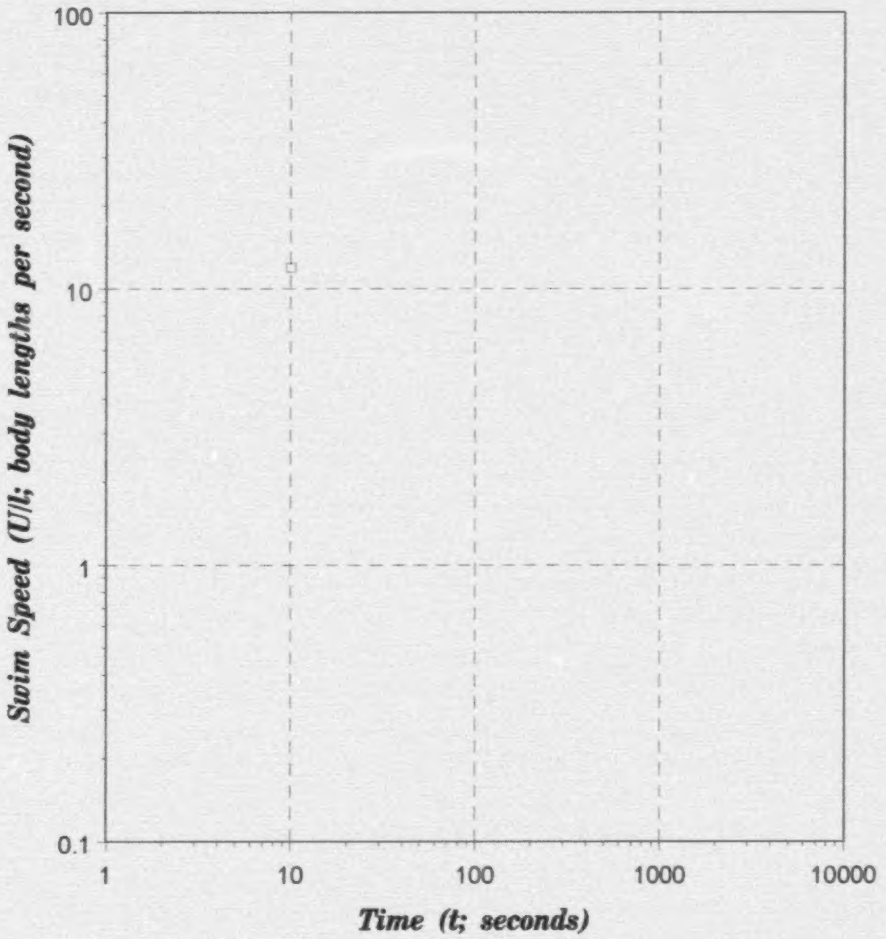


Figure B-035. Processed data for Fundulus zebrinus *(Plains Killifish): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-035. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	23.6	0	23.6	23.6	0	1
U (m/s)	0.434	0	0.434	0.434	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

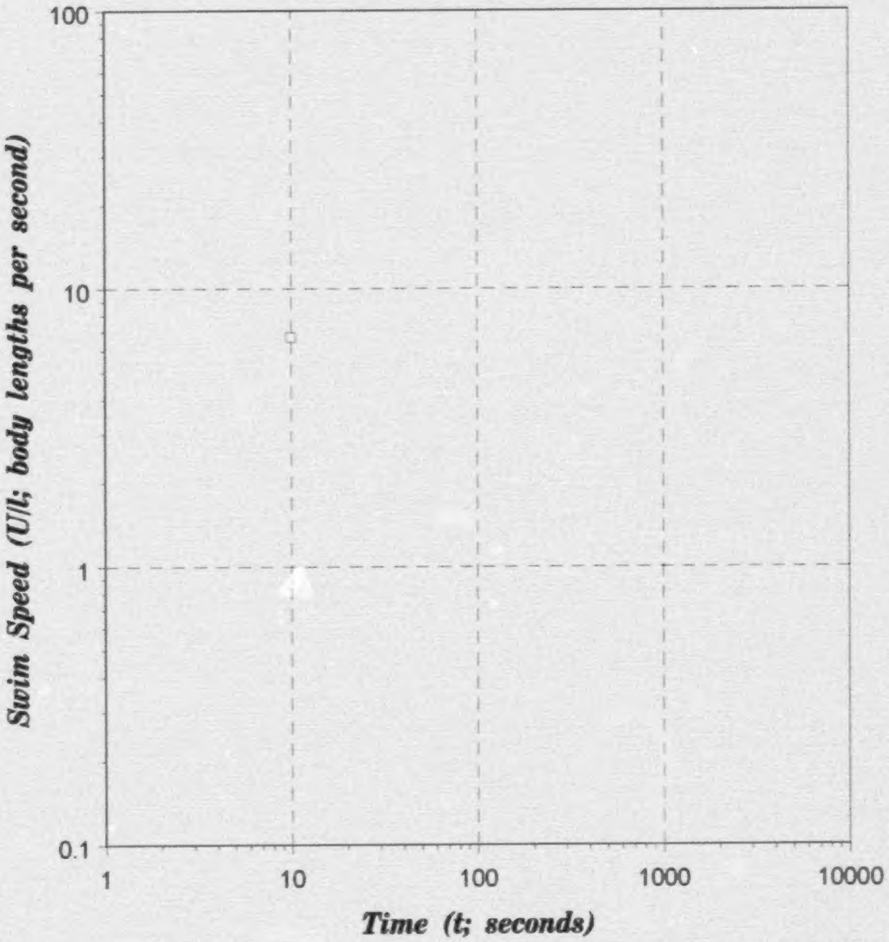
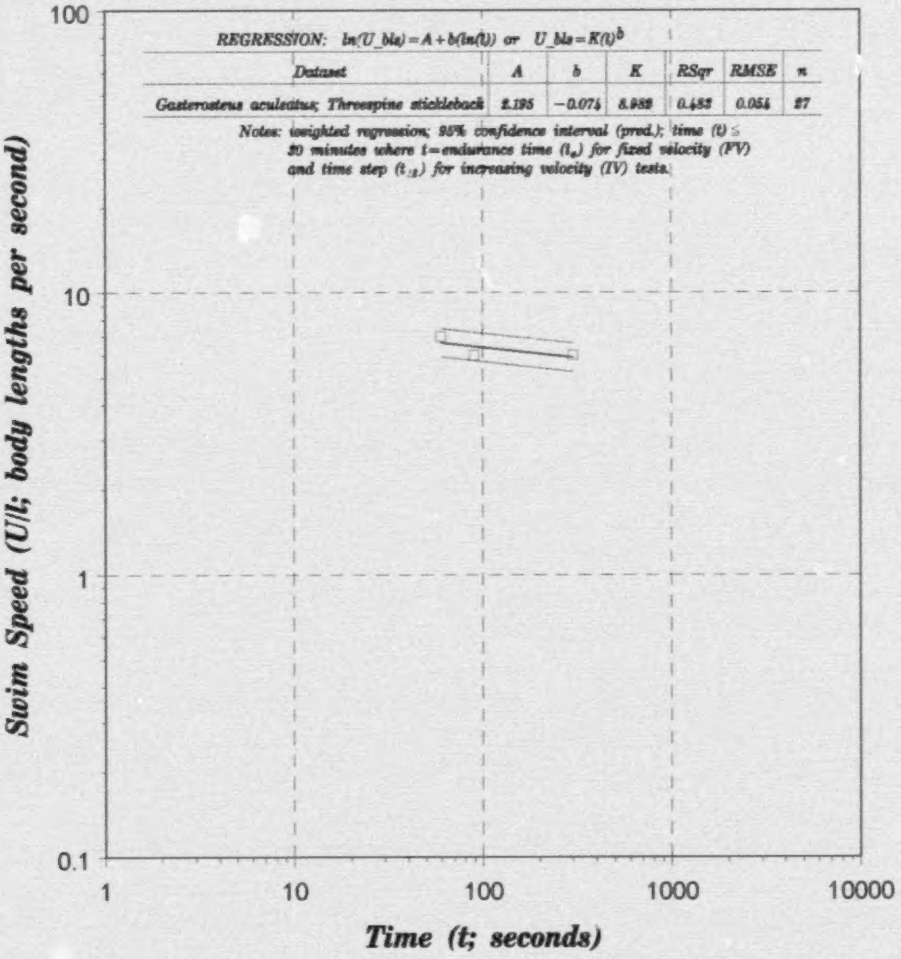


Figure B-036. Processed data for Gambusia geiseri *(Largespring Gambusia): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner 2009).*

Table B-036. Data summary. Fish count 7, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.023	0	0.023	0.023	0	1
T (C)	22.7	0	22.7	22.7	0	1
U (m/s)	0.157	0	0.157	0.157	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1



REGRESSION: $\ln(U\_bls) = A + b(\ln(t))$ or $U\_bls = K(t)^b$

Dataset	A	b	K	RSqr	RMSE	n
Gasterosteus aculeatus; Threespine stickleback	2.195	−0.074	8.982	0.482	0.054	27

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure B-037. Processed data for Gasterosteus aculeatus *(Threespine Stickleback): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Whoriskey and Wootton (1987).*

Table B-037. Data summary. Fish count 27, record count 3.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.048	0.003	0.044	0.05	0.006	2
T (C)	20	0	20	20	0	1
U (m/s)	0.305	0.036	0.264	0.35	0.086	3
t_e (s)	150	109	60	300	240	3
$t_{\Delta t}$ (s)	.	.	.	.	.	0

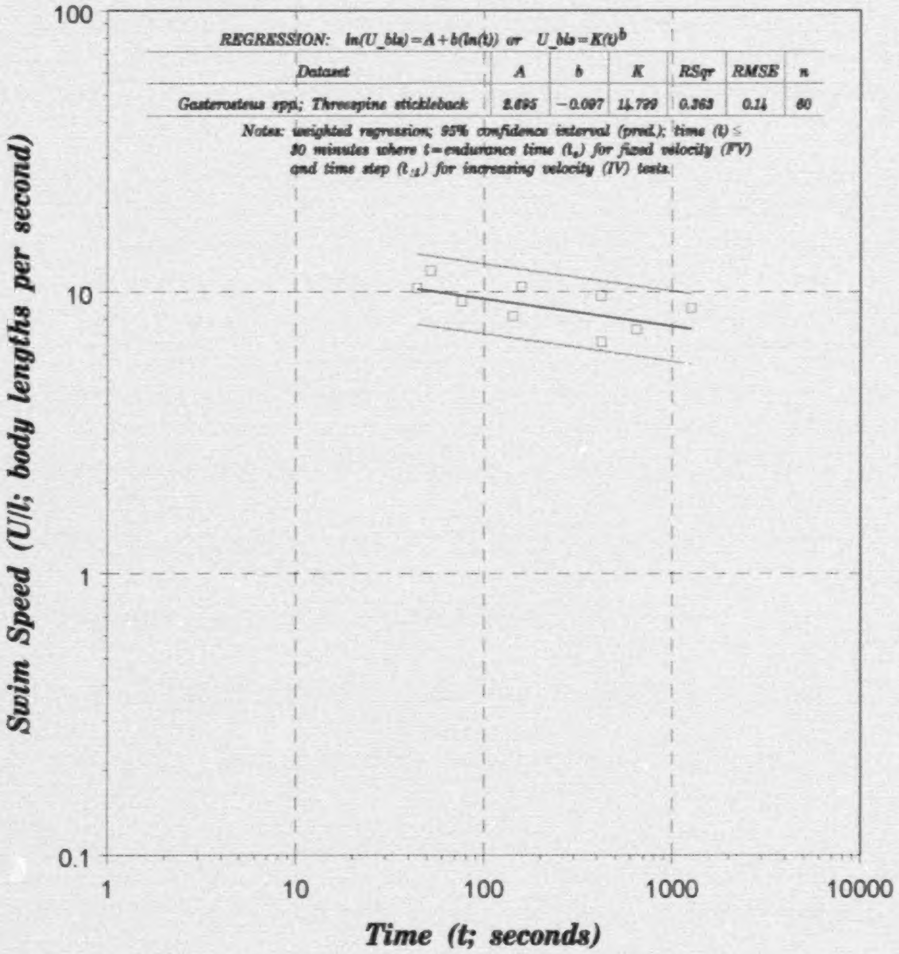


Figure B-038. Processed data for Gasterosteus aculeatus *(Paxton Lake Threespine Stickleback): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Blake et al. (2005).*

Table B-038. Data summary. Fish count 60, record count 9.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0.005	0.044	0.055	0.011	2
T (C)	15	0	15	15	0	1
U (m/s)	0.447	0.062	0.368	0.571	0.203	9
t_e (s)	381	361	44	1261	1217	9
$t_{\Delta t}$ (s)	.	.	.	.	.	0

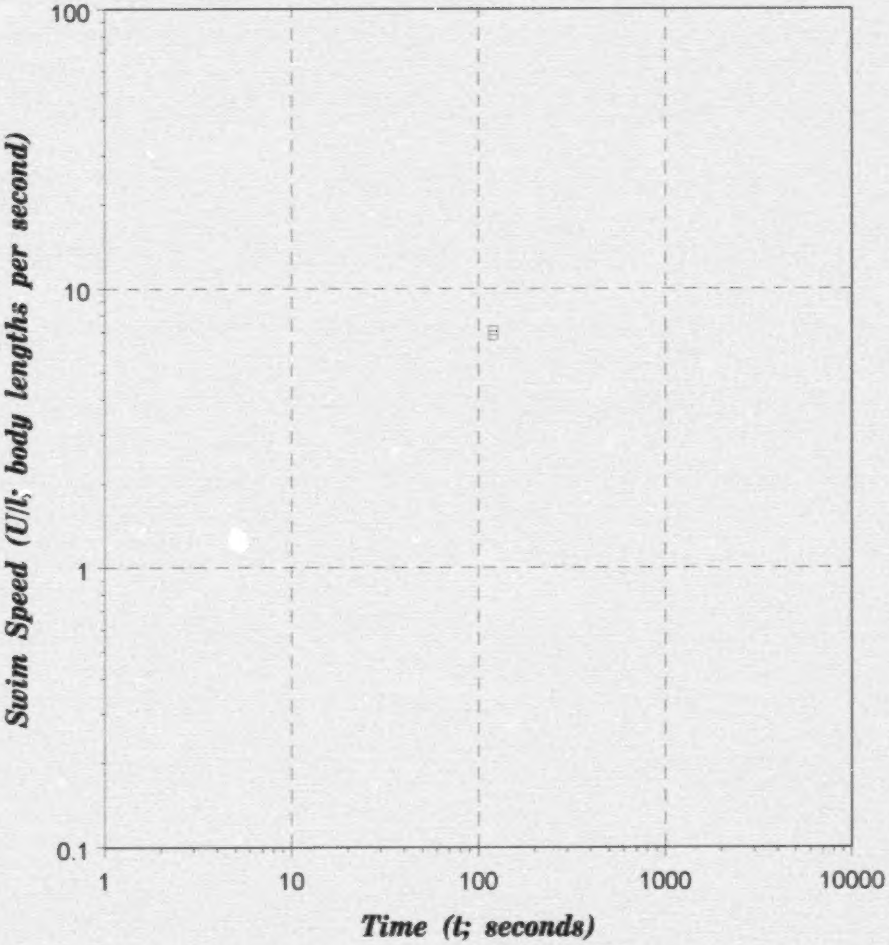


Figure B-039. Processed data for Gila cypha *(Humpback Chub): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Berry and Pimentel (1985).*

Table B-039. Data summary. Fish count 156, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.096	0.003	0.093	0.099	0.006	2
T (C)	23.3	3	20	26	6	2
U (m/s)	0.668	0.035	0.63	0.7	0.07	2
t_e (s)	120	0	120	120	0	1
$t_{\Delta t}$ (s)	.	.	.	.	.	0

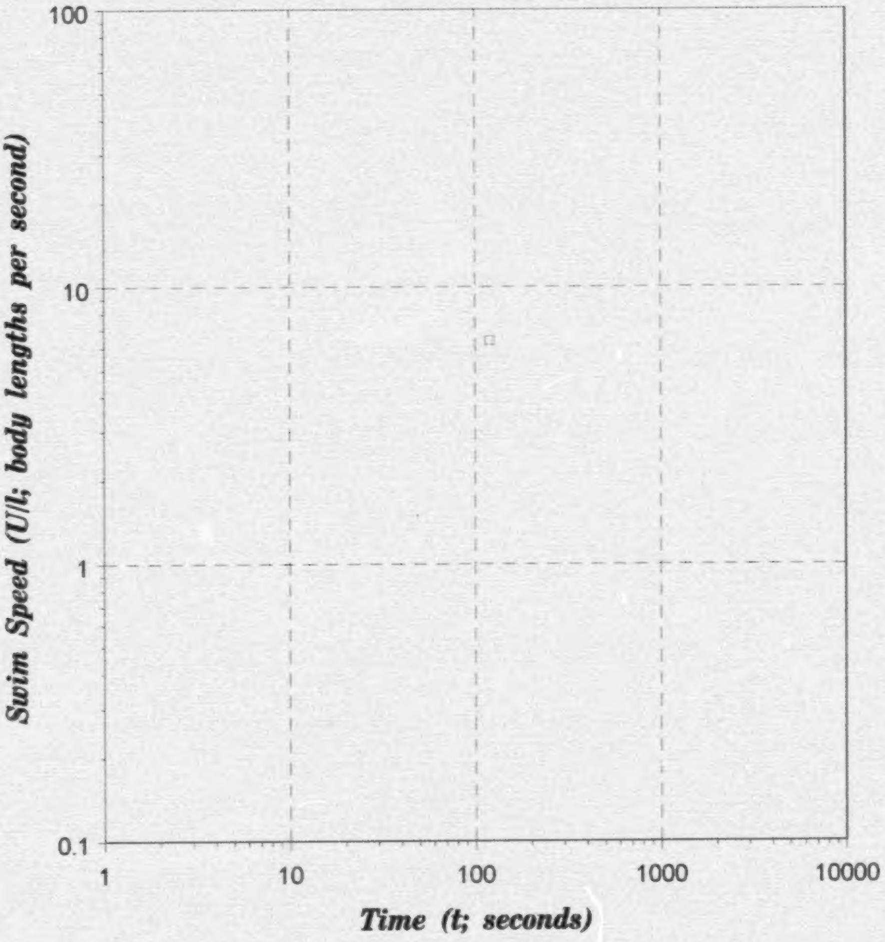


Figure B-040. Processed data for Gila elegans *(Bonytail Chub): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Berry and Pimentel (1985).*

Table B-040. Data summary. Fish count 59, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.097	0	0.097	0.97	0	1
T (C)	20	0	20	20	0	1
U (m/s)	0.62	0	0.62	0.62	0	1
t_e (s)	120	0	120	120	0	1
$t_{\Delta t}$ (s)	.	.	.	.	.	0

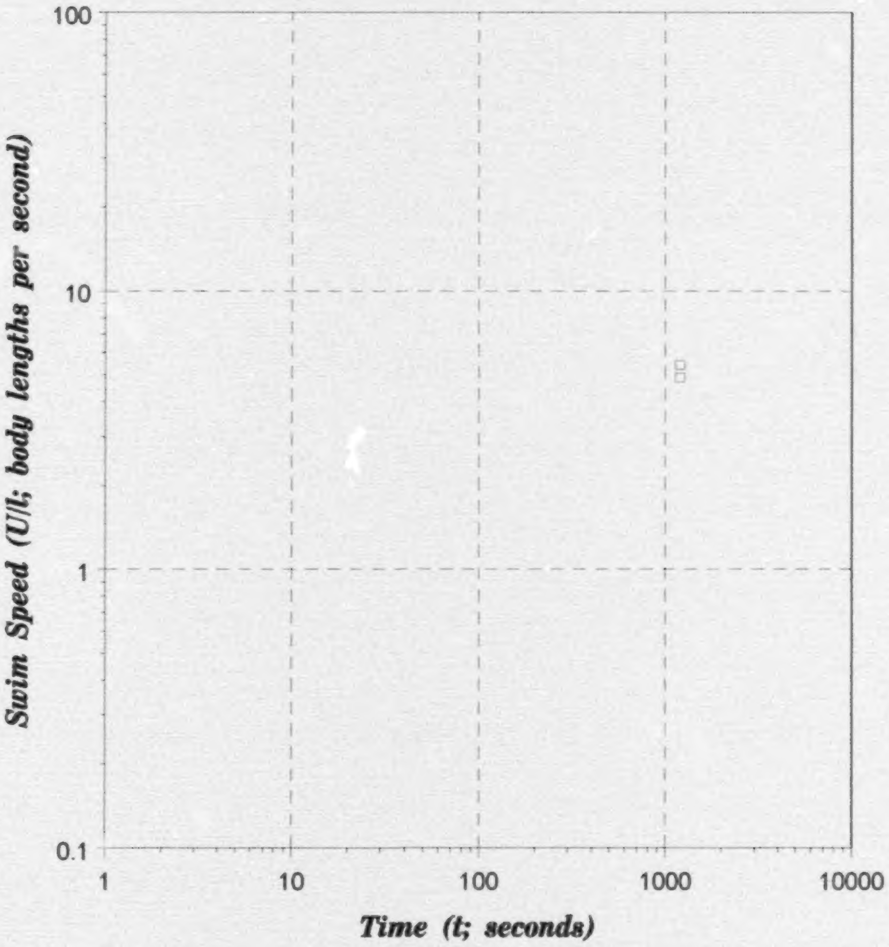


Figure B-041. Processed data for Gobio gobio *(Gudgeon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Tudorache et al. (2008).*

Table B-041. Data summary. Fish count 16, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.112	0.012	0.1	0.123	0.023	2
T (C)	15	0	15	15	0	1
U (m/s)	0.572	0.031	0.542	0.602	0.06	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

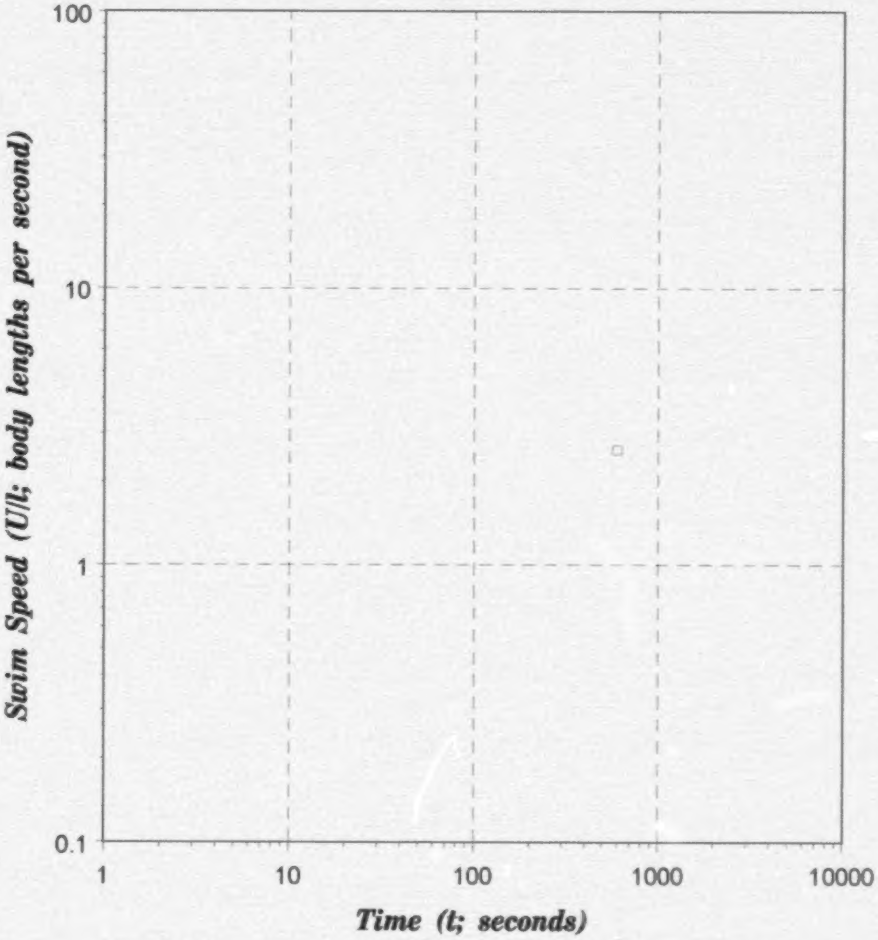


Figure B-042. Processed data for Hiodon alosoides *(Goldeye): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973).*

Table B-042. Data summary. Fish count 2, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.23	0	0.23	0.23	0	1
T (C)	16	0	16	16	0	1
U (m/s)	.06	0	0.6	0.6	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

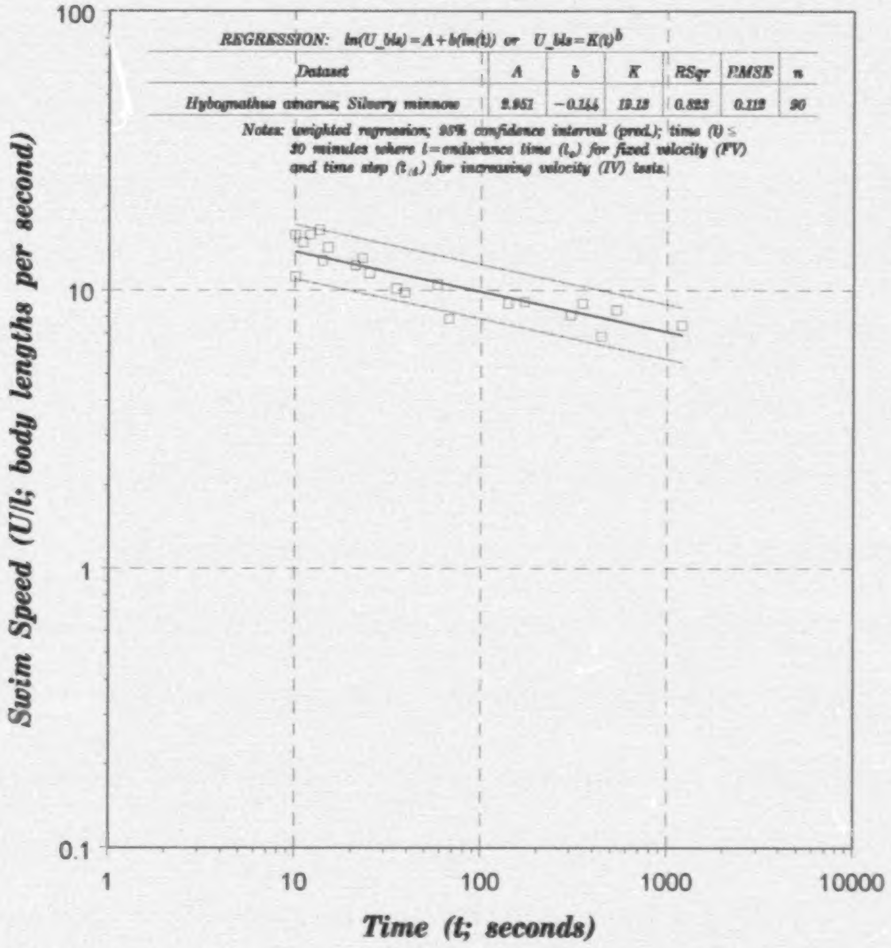


Figure B-043. Processed data for Hybognathus amarus *(Silvery Minnow): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Bestgen et al. (2003).*

Table B-043. Data summary. Fish count 90, record count 21.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.071	0.001	0.069	0.071	0.002	2
T (C)	18.9	3.1	15	23	8	3
U (m/s)	0.728	0.204	0.484	1.168	0.684	21
t_e (s)	154	176	10	532	522	19
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

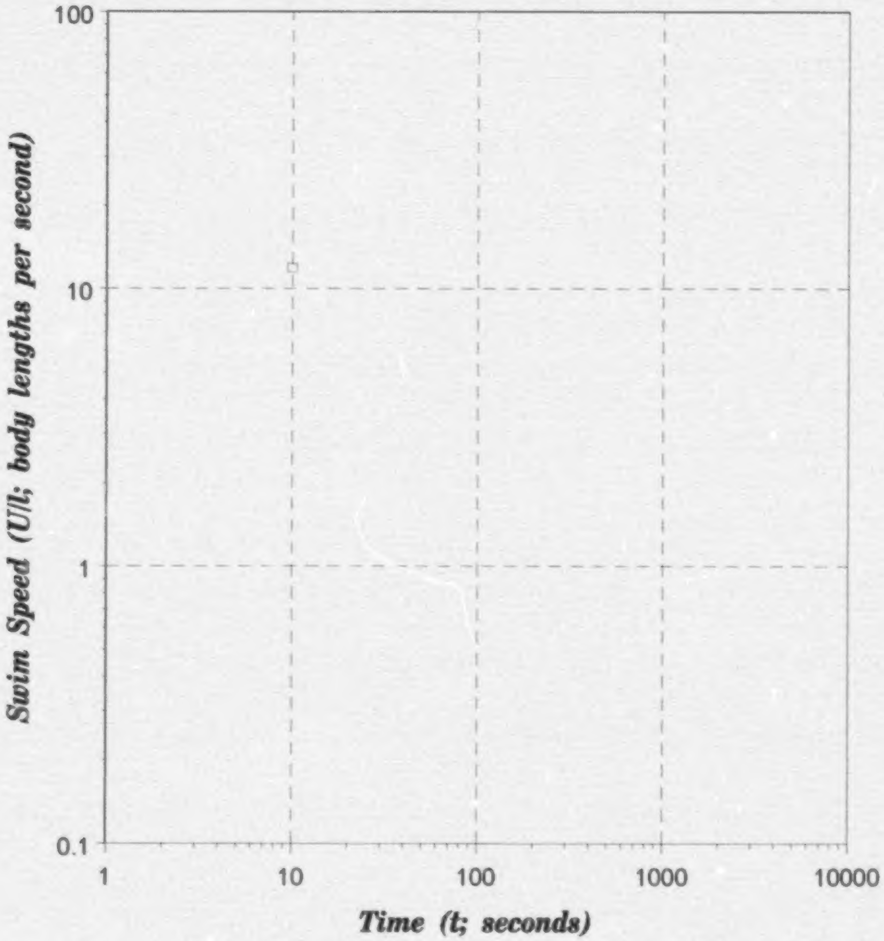


Figure B-044. Processed data for Hybognathus placitus *(Plains Minnow): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-044. Data summary. Fish count 32, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0	0.51	0.51	0	1
T (C)	28.7	0	28.7	28.7	0	1
U (m/s)	0.611	0	0.611	0.611	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

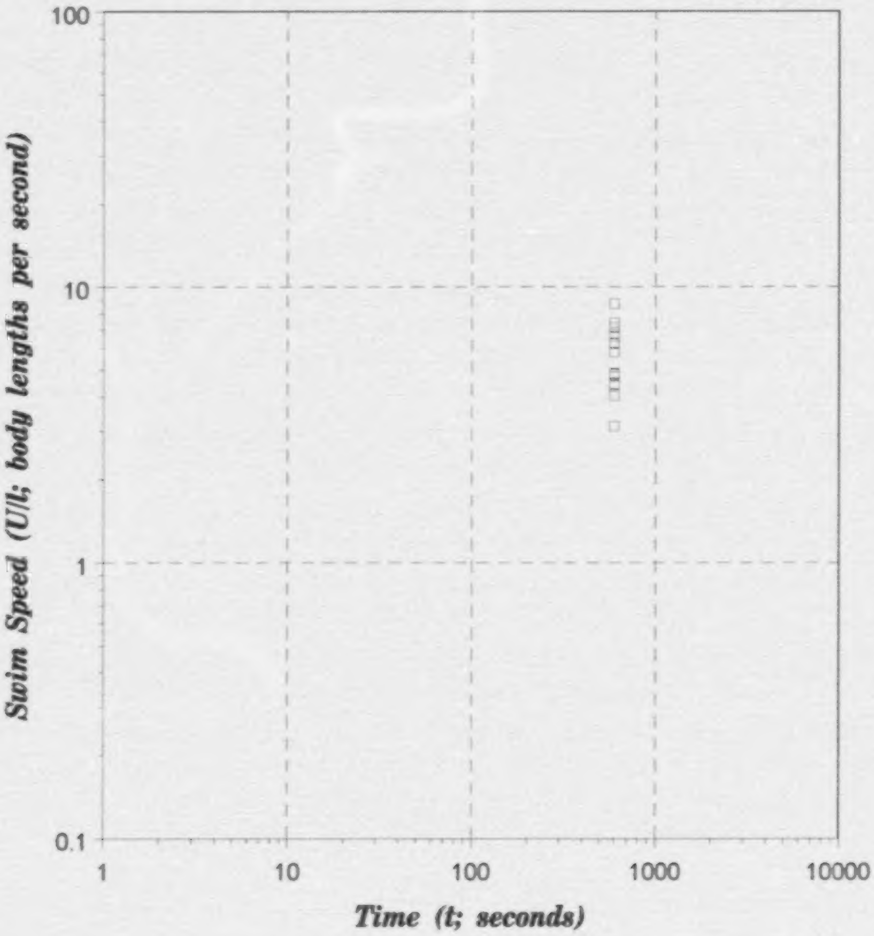


Figure B-045. Processed data for Hypomesus transpacificus *(Delta Smelt): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Swanson and Cech (1995).*

Table B-045. Data summary. Fish count 71, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.055	0.01	0.033	0.071	0.038	14
T (C)	16	3	12	21	9	3
U (m/s)	0.266	0.017	0.223	0.305	0.82	13
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

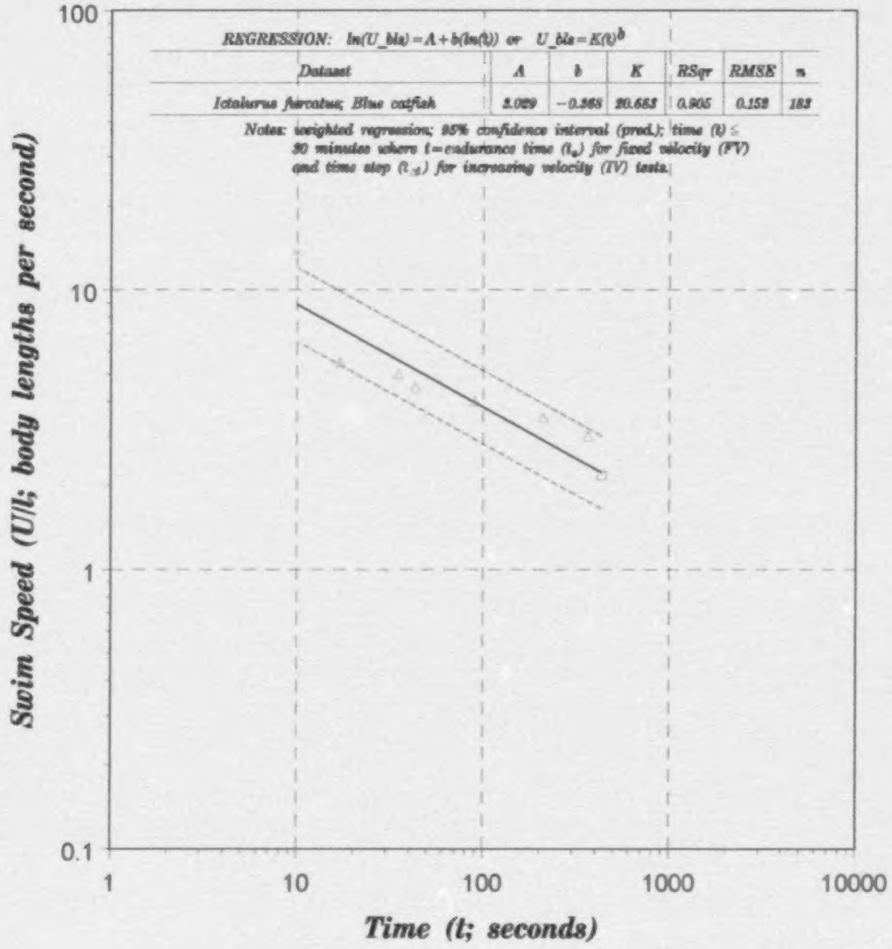
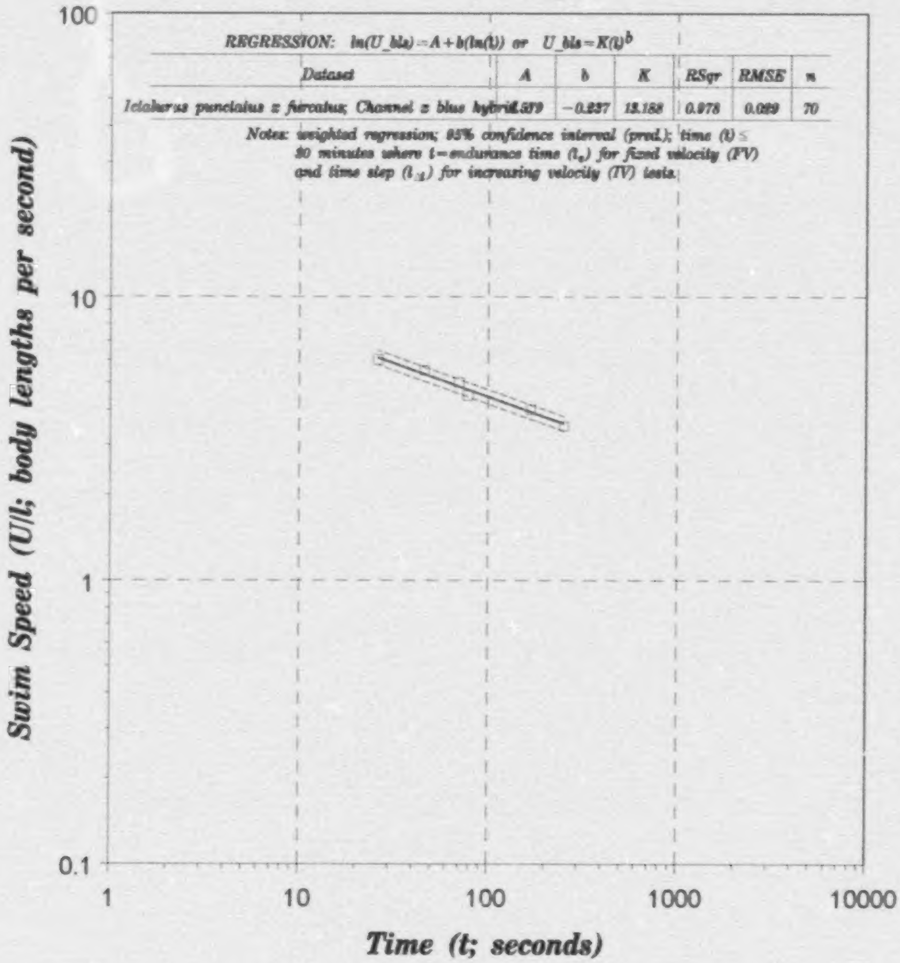


Figure B-046. Processed data for Ictalurus furcatus *(Blue Catfish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Beecham et al. (2007); red triangles are data from Beecham et al. (2009); green stars are data from Leavy and Bonner (2009).*

Table B-046. Data summary. Fish count 183, record count 8.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.234	0.058	0.052	0.277	0.225	3
T (C)	20.7	2.2	20	29.6	9.6	3
U (m/s)	0.706	0.159	0.6	1.1	0.5	6
t_e (s)	300	173	17	432	415	7
$t_{\Delta t}$ (s)	10	0	10	10	0	1



REGRESSION: $\ln(U\_bls) = A + b(\ln(t))$ or $U\_bls = K(t)^b$

Dataset	A	b	K	RSqr	RMSE	n
Ictalurus punctatus x furcatus; Channel x blue hybrid	2.579	−0.237	13.188	0.978	0.089	70

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure B-047. Processed data for Ictalurus punctatus x furcatus *(channel x blue hybrid): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Beecham et al. (2009).*

Table B-047. Data summary. Fish count 70, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.2	0	0.2	0.2	0	1
T (C)	20.5	0	20.5	20.5	0	1
U (m/s)	0.974	0.18	0.7	1.2	0.5	6
t_e (s)	99	80	26	252	226	6
$t_{\Delta t}$ (s)	.	.	.	.	.	0

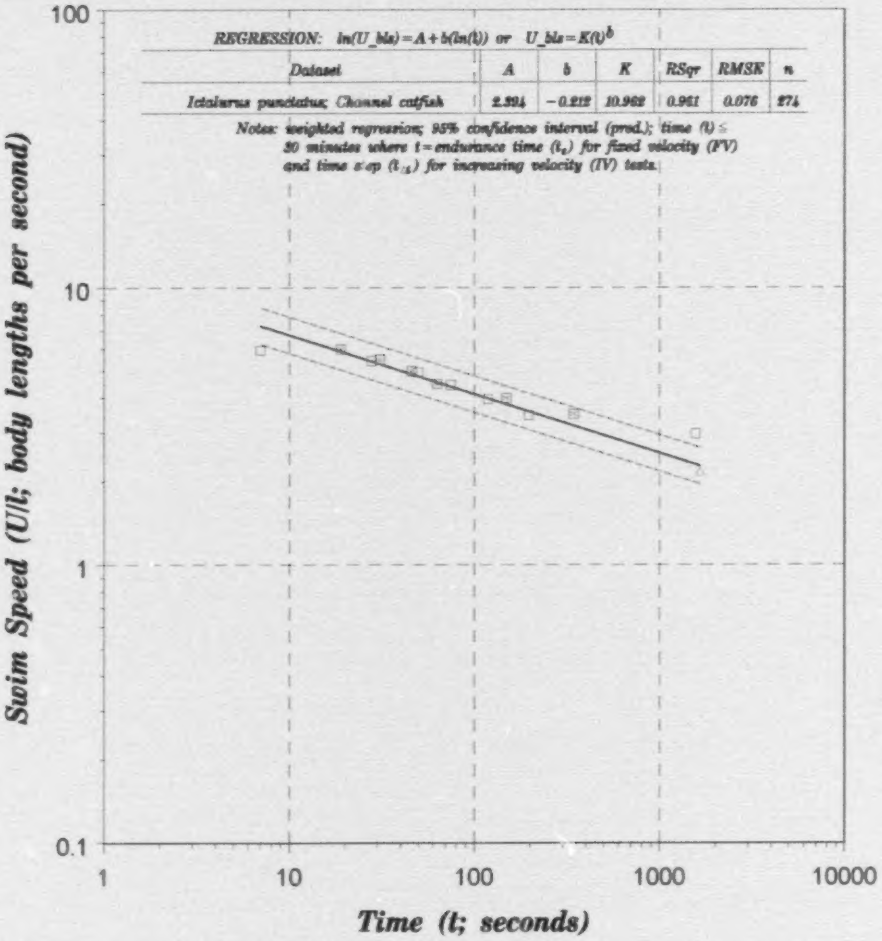


Figure B-048. Processed data for Ictalurus punctatus *(Channel Catfish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Beecham et al. (2007); red triangles are data from Beecham et al. (2007); green stars are data from Beecham et al. (2009).*

Table B-048. Data summary. Fish count 274, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.228	0.036	0.2	0.276	0.076	3
T (C)	20.3	0.2	20	20.5	0.5	2
U (m/s)	0.801	0.211	0.6	1.2	0.6	7
t_e (s)	725	762	7	1656	1649	14
$t_{\Delta t}$ (s)	.	.	.	.	.	0

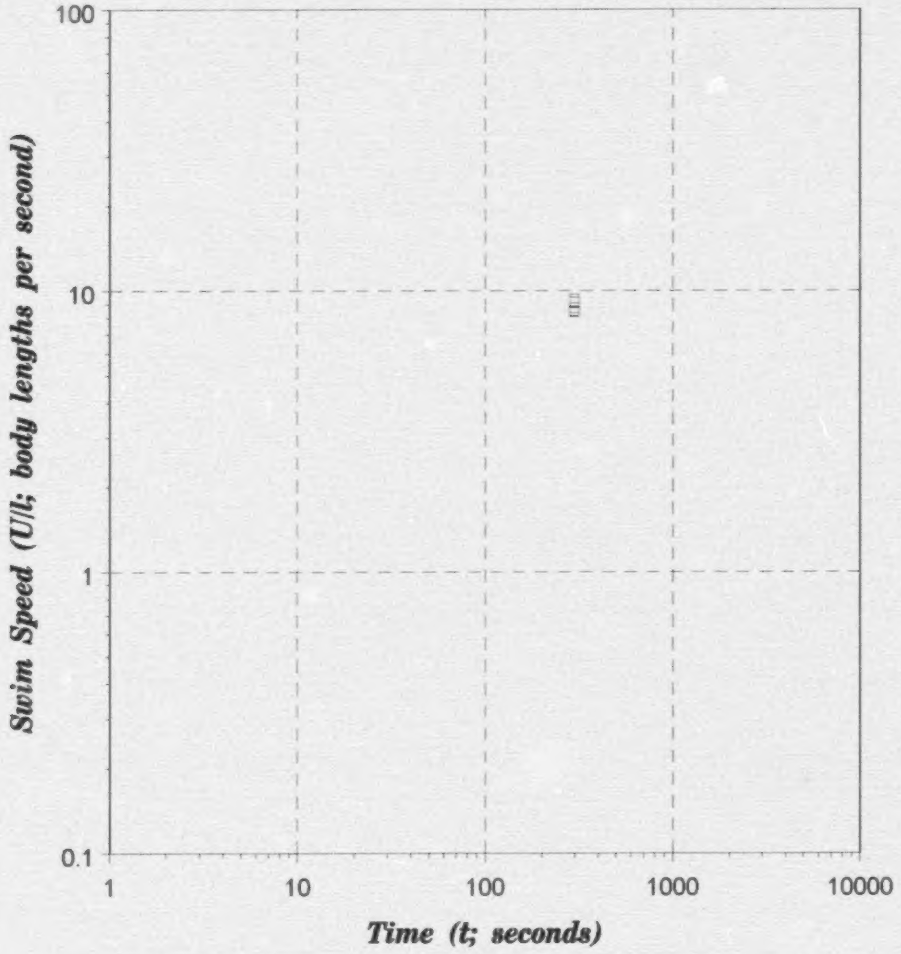


Figure B-049. Processed data for Iotichthys phlegethontis *(Least Chub): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Aedo et al. (2009)*

Table B-049. Data summary. Fish count 40, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.033	0.004	0.025	0.041	0.016	5
T (C)	17	0	17	17	0	1
U (m/s)	0.285	0.028	0.234	0.344	0.11	5
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

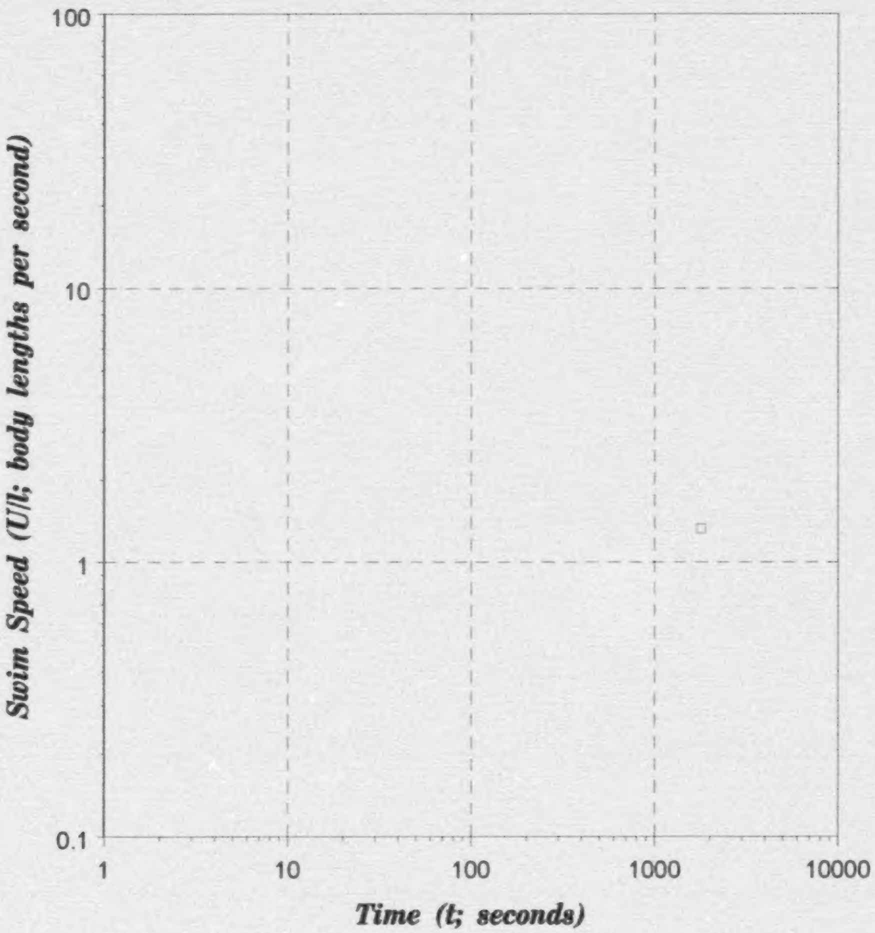


Figure B-050. Processed data for Lampetra tridentata *(Pacific Lamprey): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Mesa et al. (2003a).*

Table B-050. Data summary. Fish count 24, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.641	0	0.641	0.641	0	1
T (C)	15	0	15	15	0	1
U (m/s)	0.851	0	0.851	0.851	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

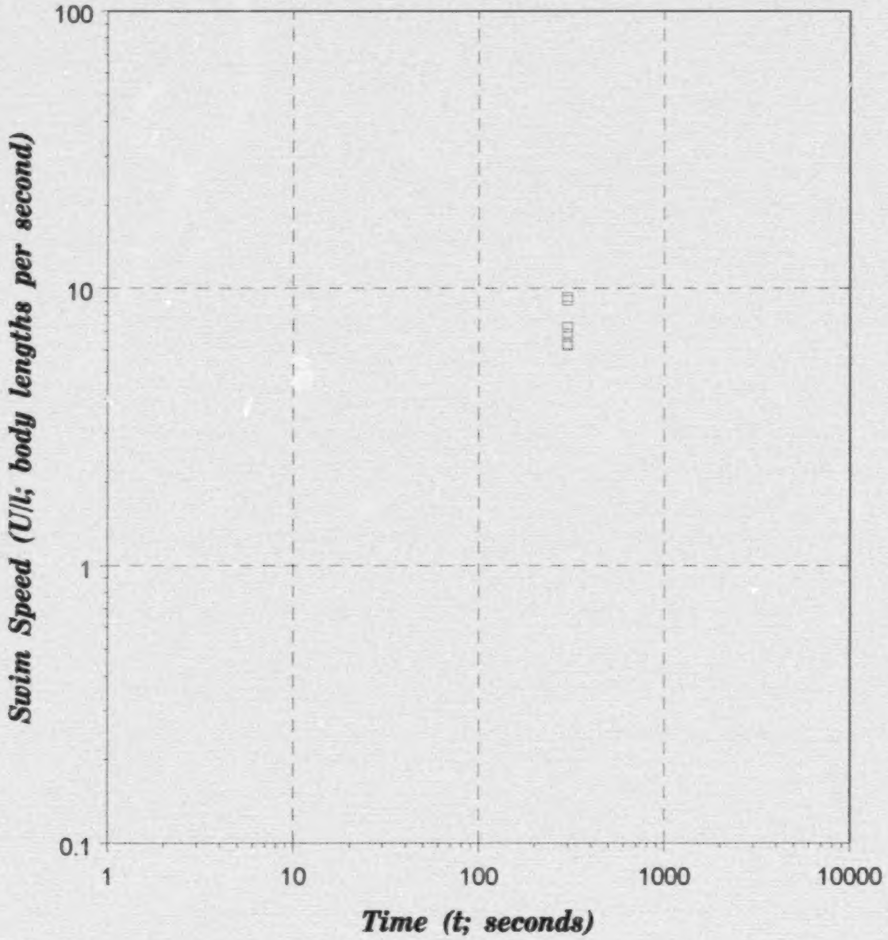


Figure B-051. Processed data for Lepidomeda aliciae *(Southern Leatherside Chub): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Aedo et al. (2009).*

Table B-051. Data summary. Fish count 21, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.078	0.019	0.004	0.104	0.064	6
T (C)	17	0	17	17	0	1
U (m/s)	0.542	0.112	0.373	0.717	0.344	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

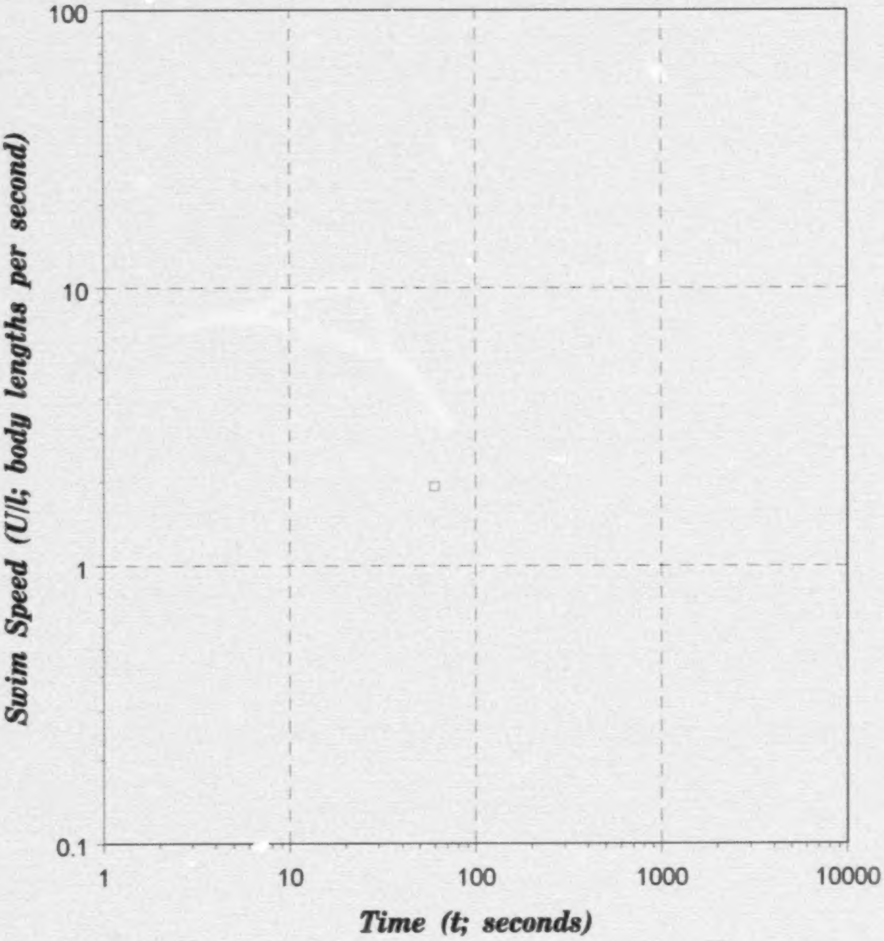


Figure B-052. Processed data for Lepisosteus osseus *(Longnose Gar): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Webb et al. (1992).*

Table B-052. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.266	0	0.266	0.266	0	1
T (C)	25	0	25	25	0	1
U (m/s)	0.514	0	0.514	0.514	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	60	0	60	60	0	1

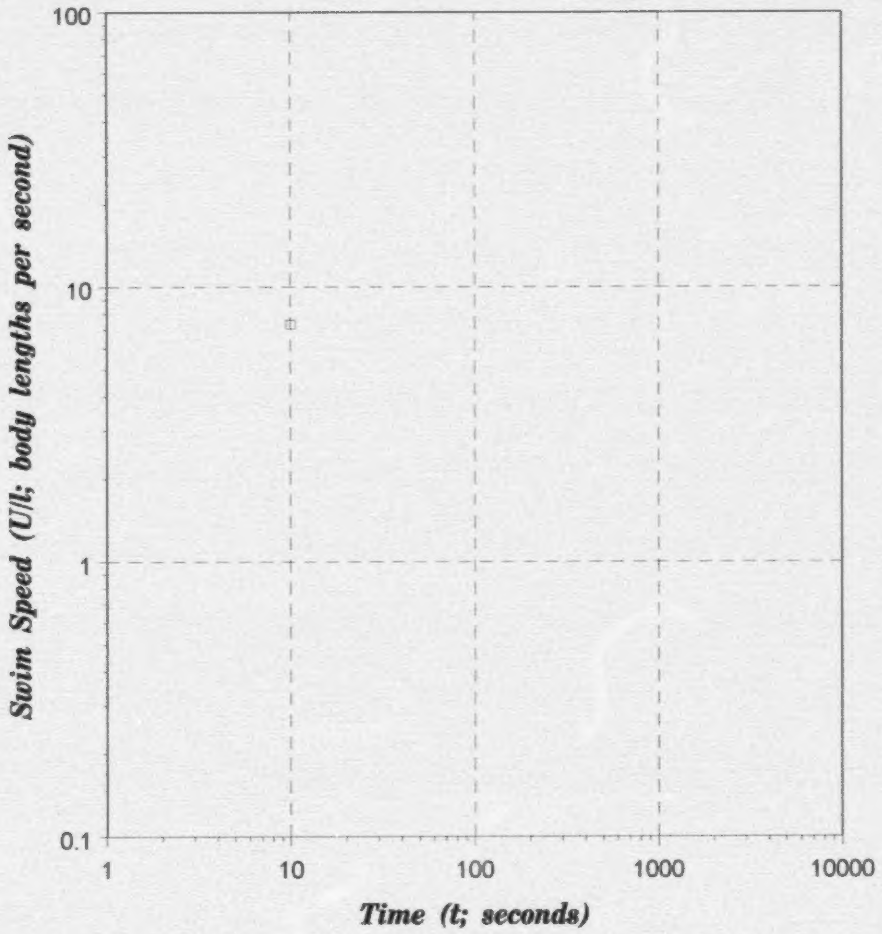


Figure B-053. Processed data for Lepomis auritus *(Redbreast Sunfish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Leavy and Bonner (2009).*

Table B-053. Data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.048	0	0.048	0.048	0	1
T (C)	26.7	0	26.7	26.7	0	1
U (m/s)	0.354	0	0.354	0.354	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

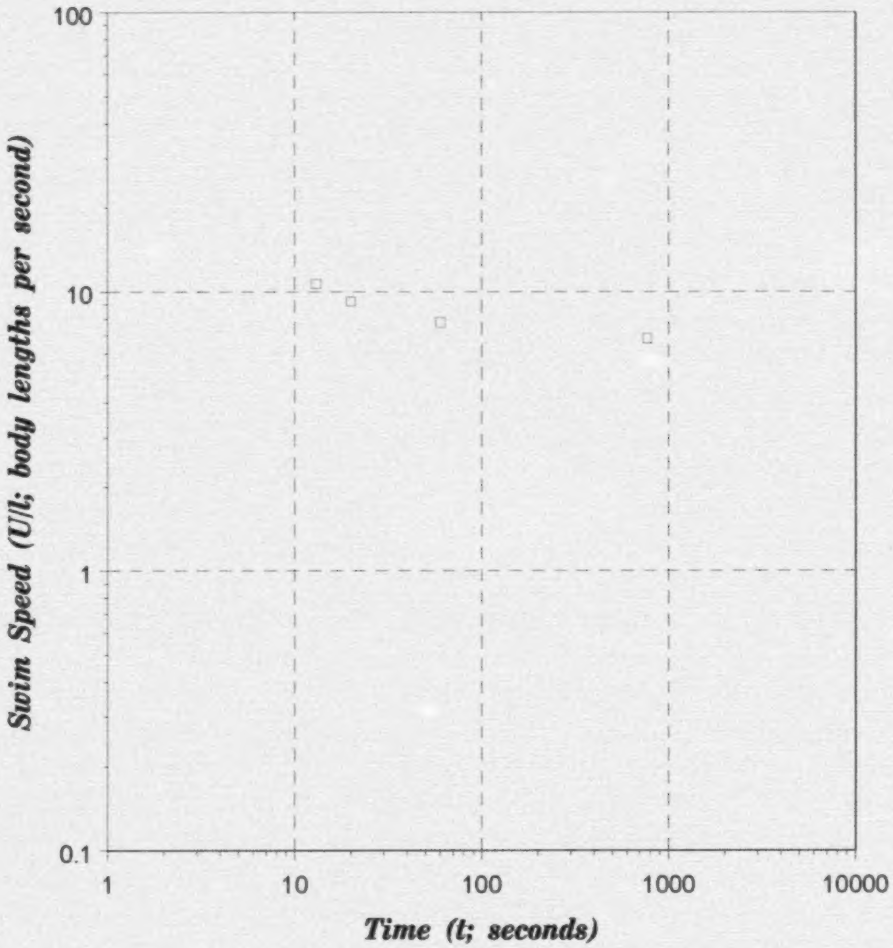


Figure B-054. Processed data for Lepomis incisor *(Sunfish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Tsukamoto et al. (1975).*

Table B-054. Data summary. Fish count 20, record count 4.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.103	0	0.103	0.103	0	1
T (C)	22	0	22	22	0	1
U (m/s)	0.888	0.155	0.7	1.1	0.4	4
t_e (s)	216	329	13	770	757	4
$t_{\Delta t}$ (s)	.	.	.	.	.	0

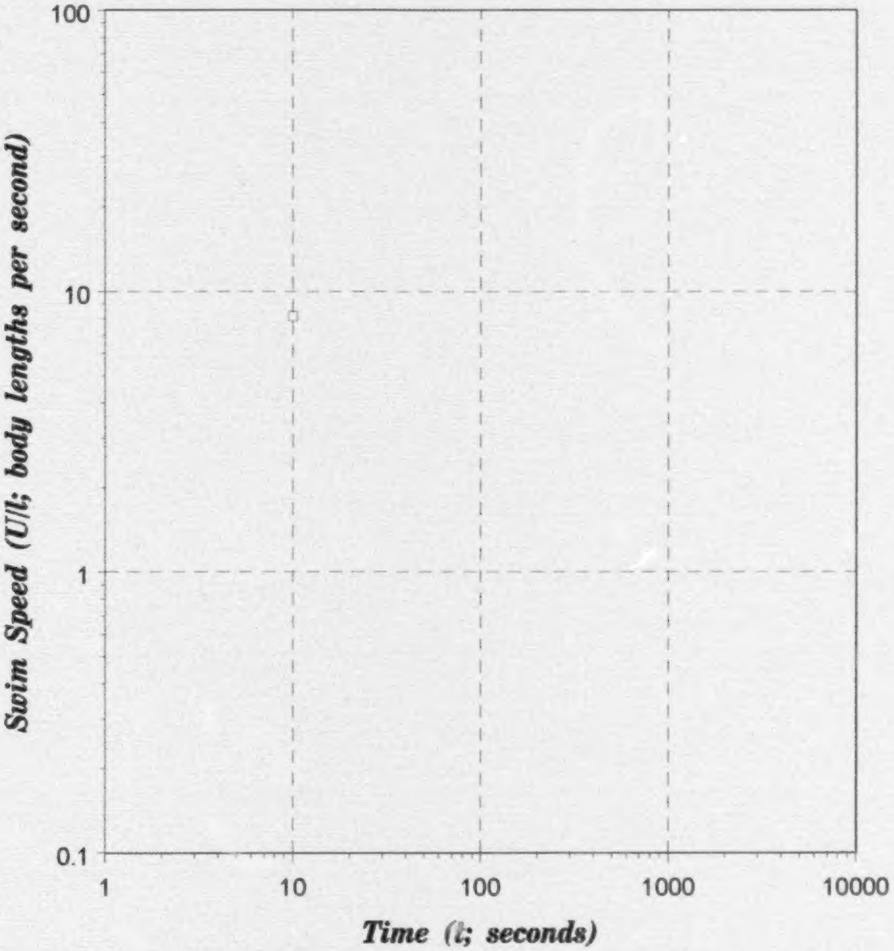


Figure B-055. Processed data for Lepomis macrochirus *(Bluegill):time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-055. Data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.05	0	0.05	0.05	0	1
T (C)	25.3	0	25.3	25.3	0	1
U (m/s)	0.405	0	0.405	0.405	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

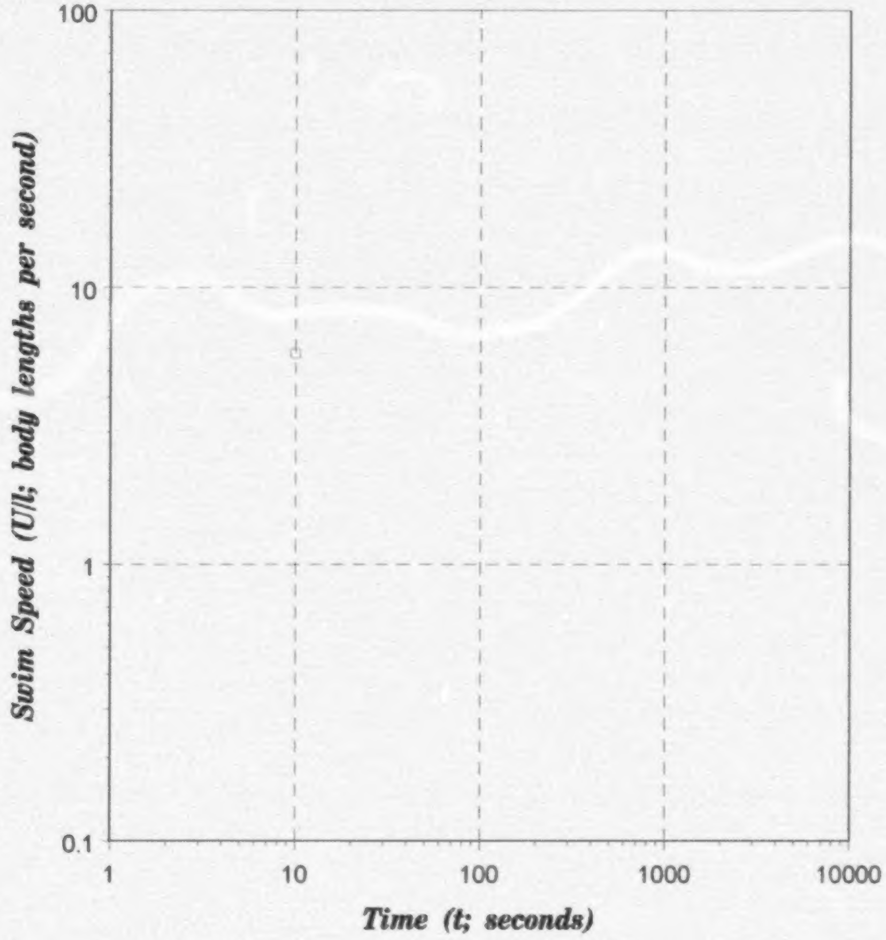


Figure B-056. Processed data for Lepomis megalotis *(Longear Sunfish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Leavy and Bonner (2009).*

Table B-056. Data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.049	0	0.049	0.049	0	1
T (C)	24.4	0	24.4	24.4	0	1
U (m/s)	0.28	0	0.28	0.28	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

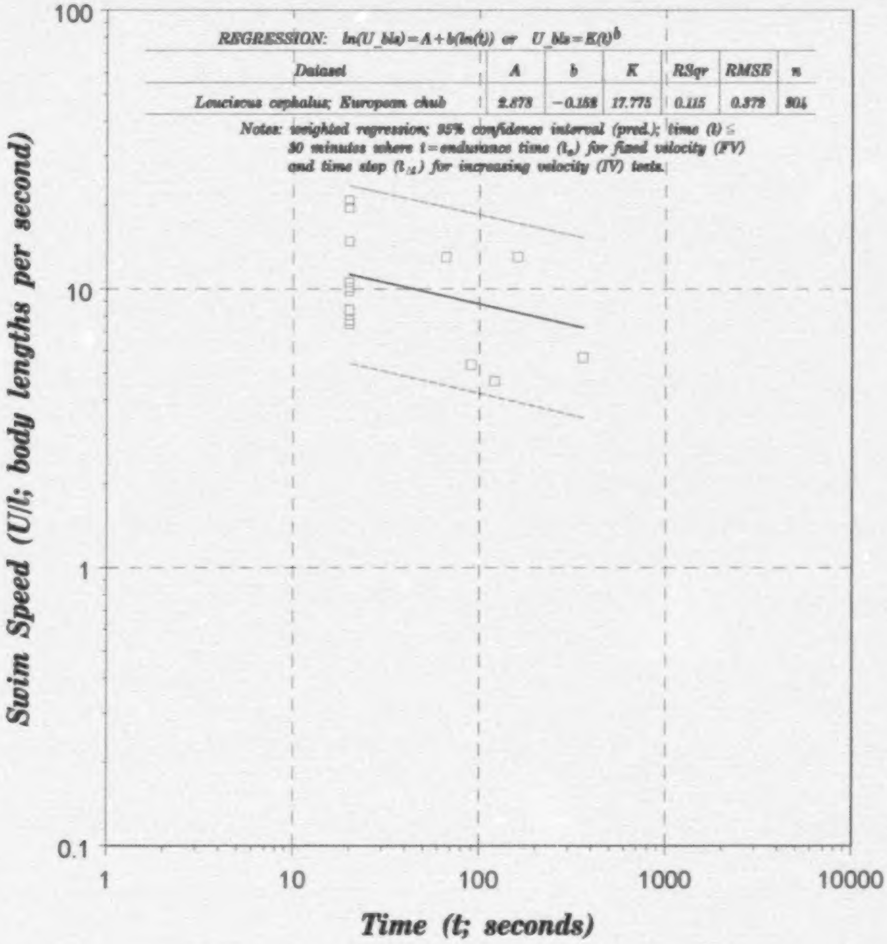


Figure B-057. Processed data for Leuciscus cephalus *(European Chub): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Clough and Turnpenny (2000).*

Table B-057. Data summary. Fish count 304, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.12	0.055	0.05	0.202	0.152	13
T (C)	13.3	4.1	8.4	20	11.6	13
U (m/s)	1.156	0.286	0.65	1.556	0.906	12
t_e (s)	161	109	66	360	294	5
$t_{\Delta t}$ (s)	20	0	20	20	0	1

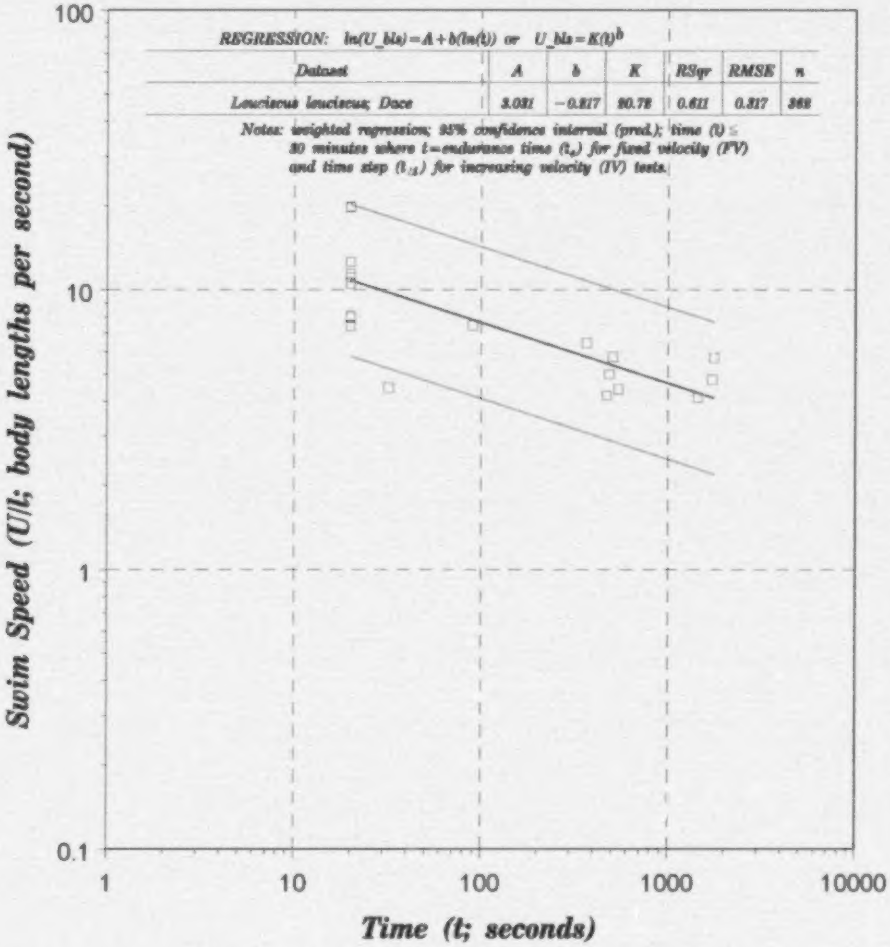


Figure B-058. Processed data for Leuciscus leuciscus *(Dace): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Clough and Turnpenny (2000).*

Table B-058. Data summary. Fish count 362, record count 19.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.141	0.049	0.05	0.192	0.142	17
T (C)	14.6	5.1	4.1	20.9	16.8	17
U (m/s)	1.079	0.335	0.45	1.547	1.097	14
t_e (s)	920	619	32	1758	1726	10
$t_{\Delta t}$ (s)	20	0	20	20	0	1

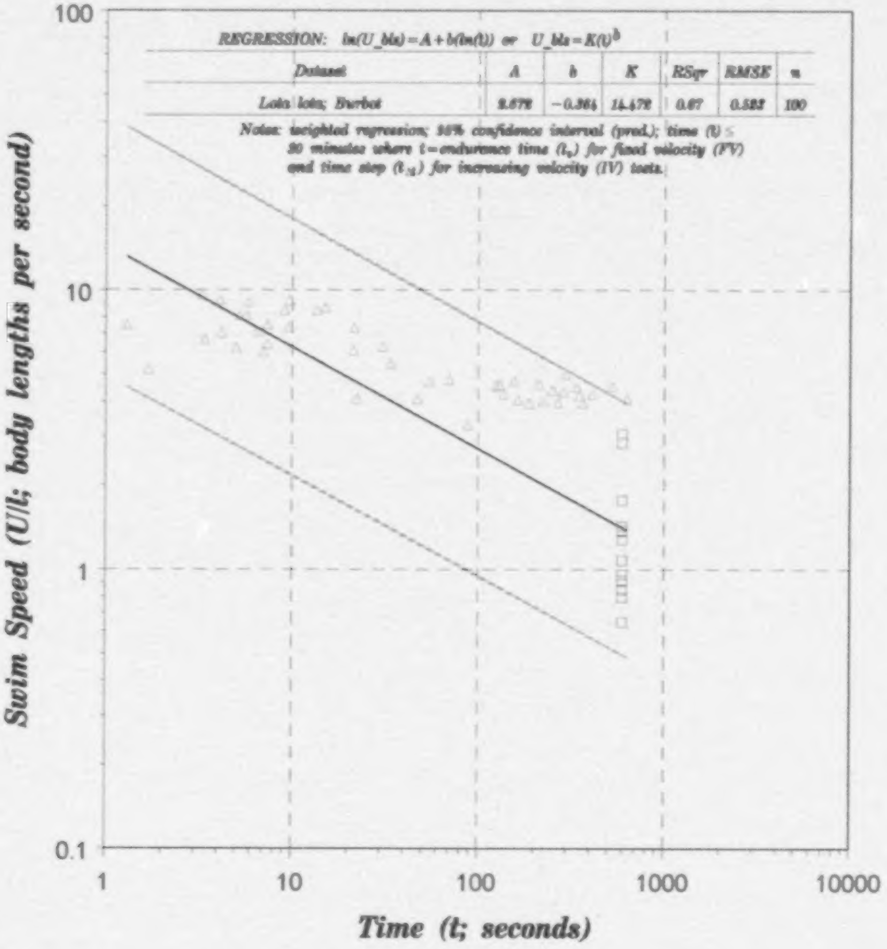


Figure B-059. Processed data for Lota lota *(Burbot): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973); red triangles are data from Vokoun and Watrous (2009).*

Table B-059. Data summary. Fish count 100, record count 60.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.296	0.135	0.12	0.63	0.51	34
T (C)	13.8	4	10	18	8	2
U (m/s)	0.753	0.45	0.339	0.91	1.571	56
t_e (s)	117	156	-	635	635	47
$t_{\Delta t}$ (s)	600	0	600	600	0	1

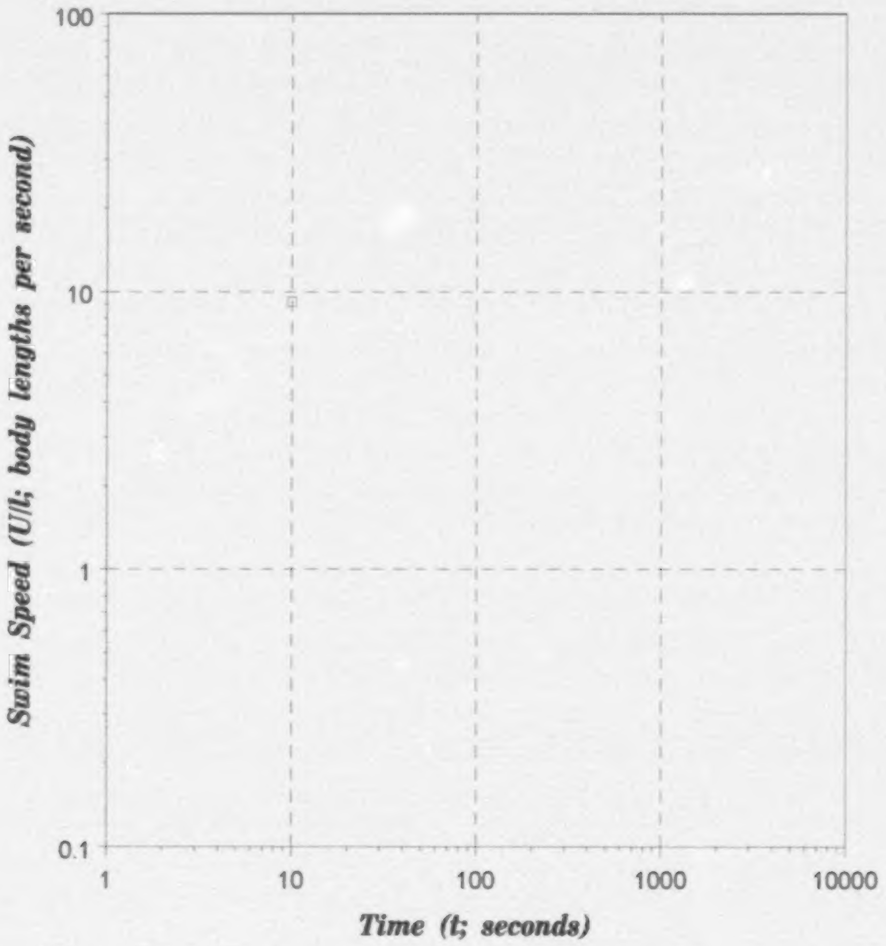


Figure B-060. Processed data for Luxilus chrysocephalus *(Striped Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-060. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.044	0	0.044	0.044	0	1
T (C)	27.5	0	27.5	27.5	0	1
U (m/s)	0.403	0	0.403	0.403	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

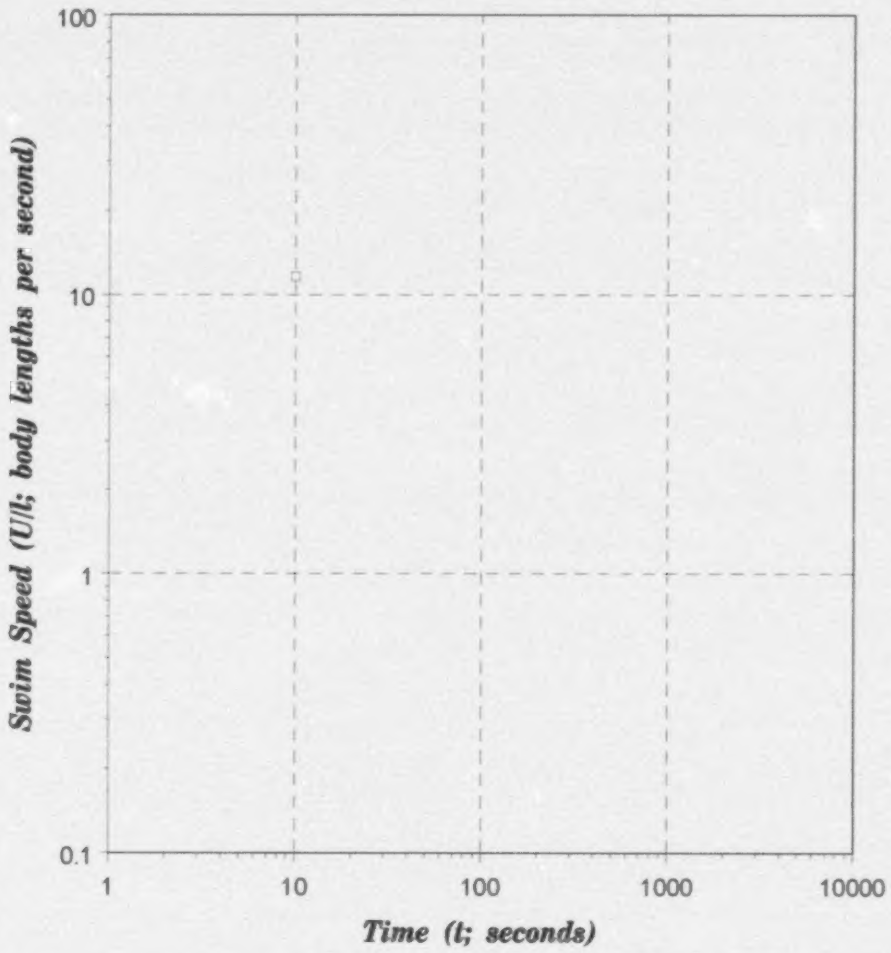


Figure B-061. Processed data for Lythrurus fumeus *(Ribbon Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-061. Data summary. Fish count 11, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.033	0	0.033	0.033	0	1
T (C)	27.2	0	27.2	27.2	0	1
U (m/s)	0.381	0	0.381	0.381	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

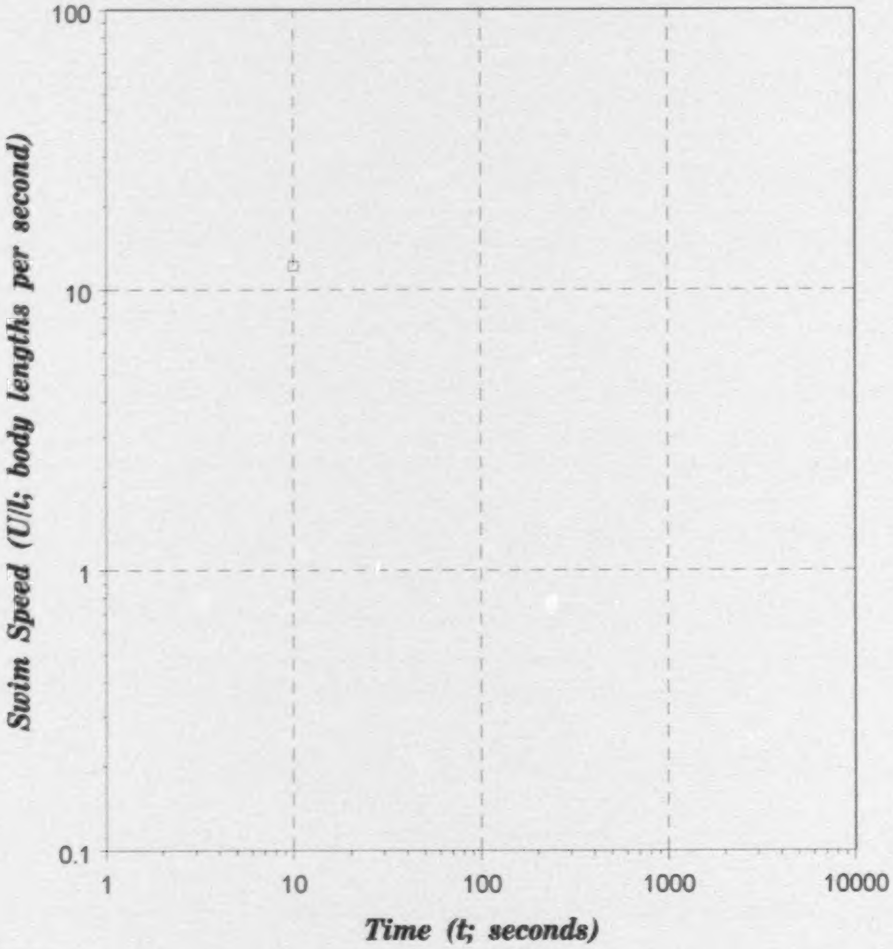


Figure B-062. Processed data for Lythrurus umbratilis *(Redfin Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Leavy and Bonner (2009).*

Table B-062. Data summary. Fish count 13, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.045	0	0.045	0.045	0	1
T (C)	29	0	29	29	0	1
U (m/s)	0.55	0	0.55	0.55	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

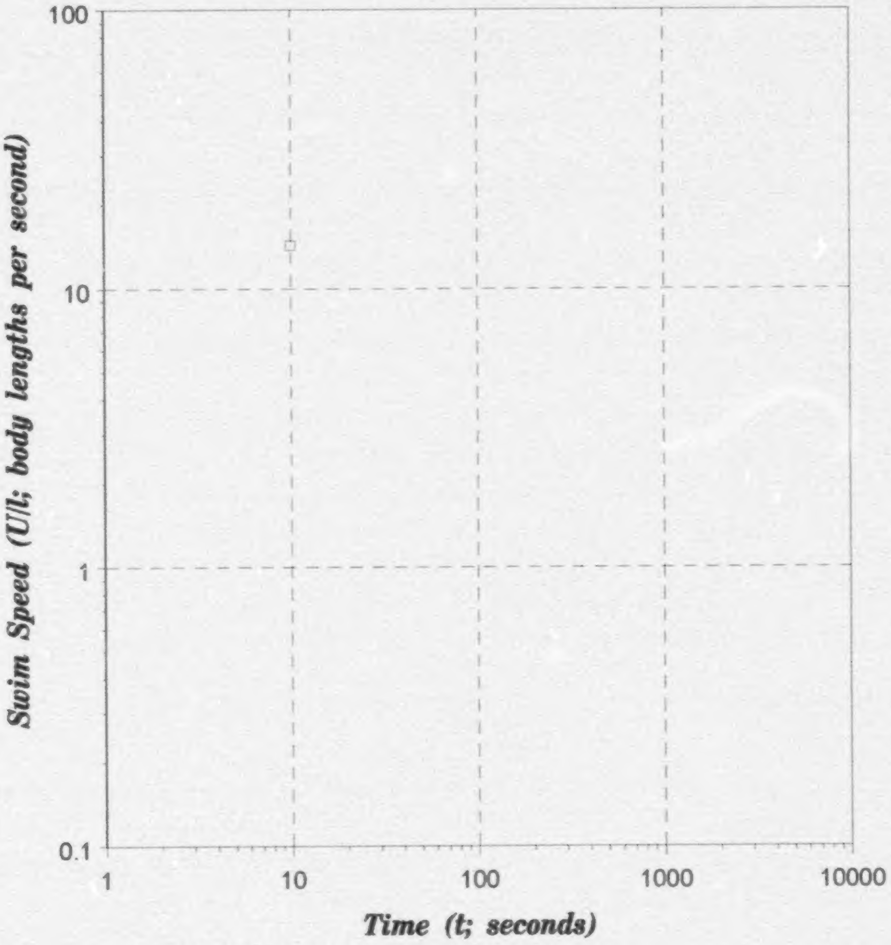


Figure B-063. Processed data for Macrhybopsis aestivalis *(Speckled Chub): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-063. Data summary. Fish count 11, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	25.3	0	25.3	25.3	0	1
U (m/s)	0.619	0	0.619	0.619	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

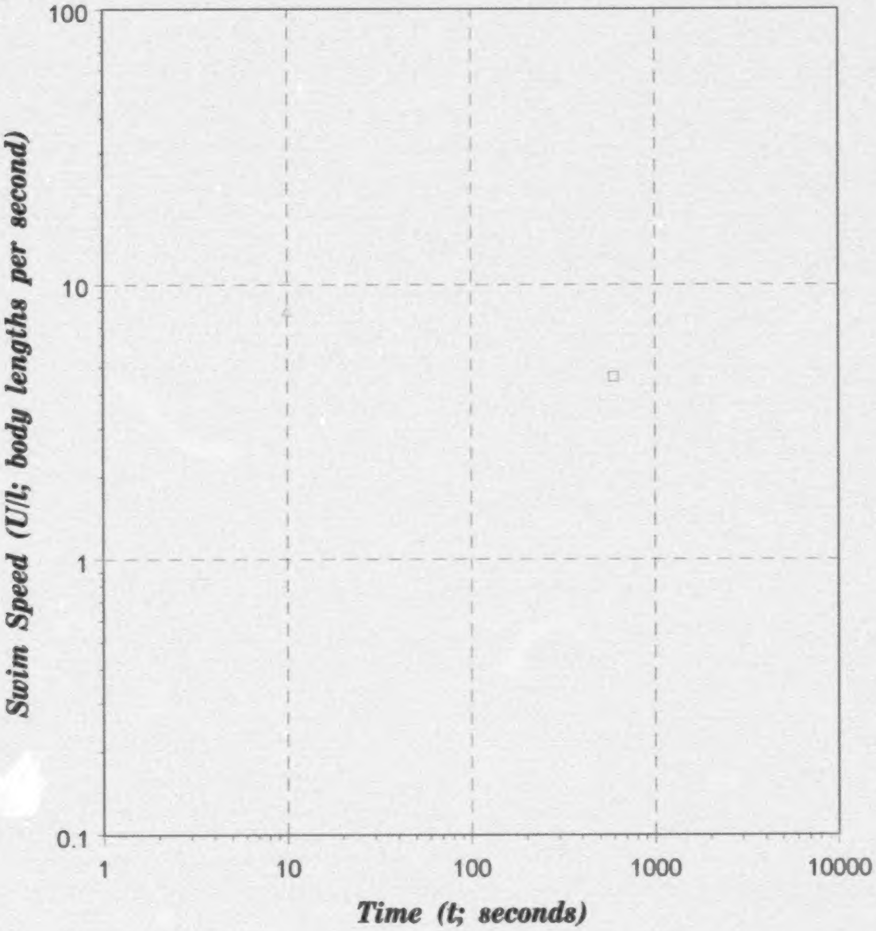


Figure B-064. Processed data for Menidia beryllina *(Inland Silverside): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Swanson and Cech (1995); red triangles are data from Leavy and Bonner (2009).*

Table B-064. Data summary. Fish count 26, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.056	0.013	0.038	0.065	0.27	2
T (C)	22.1	7.1	17	31.7	14.7	2
U (m/s)	0.301	0.001	0.3	0.302	0.002	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	396	286	10	600	590	2

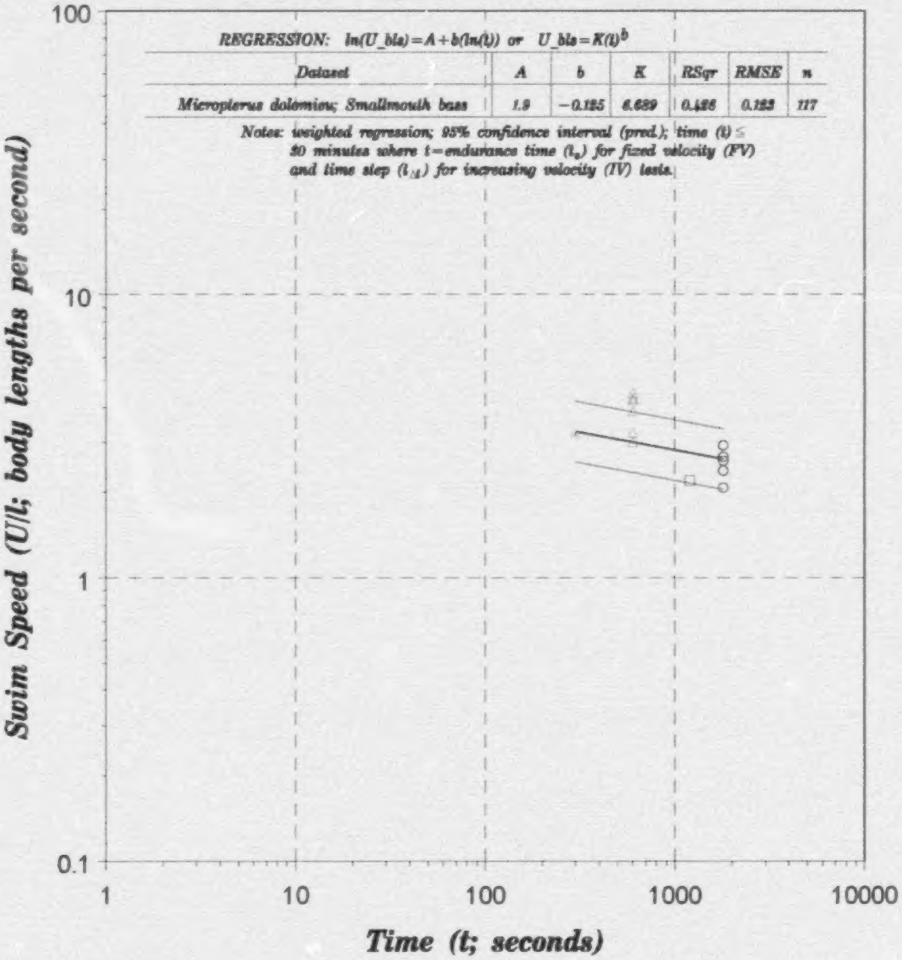


Figure B-065. Processed data for Micropterus dolomieu *(Smallmouth Bass): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from McDonald et al. (1991); red triangles are data from Bunt et al. (1999); green stars are data from Cooke and Bunt (2001); black circles are data from Peake (2004a).*

Table B-065. Data summary. Fish count 117, record count14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0.064	0.123	0.424	0.301	14
T (C)	18.2	1.5	13.5	20.3	6.8	8
U (m/s)	0.879	0.169	0.271	1.088	0.817	14
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1026	713	300	1800	1500	4

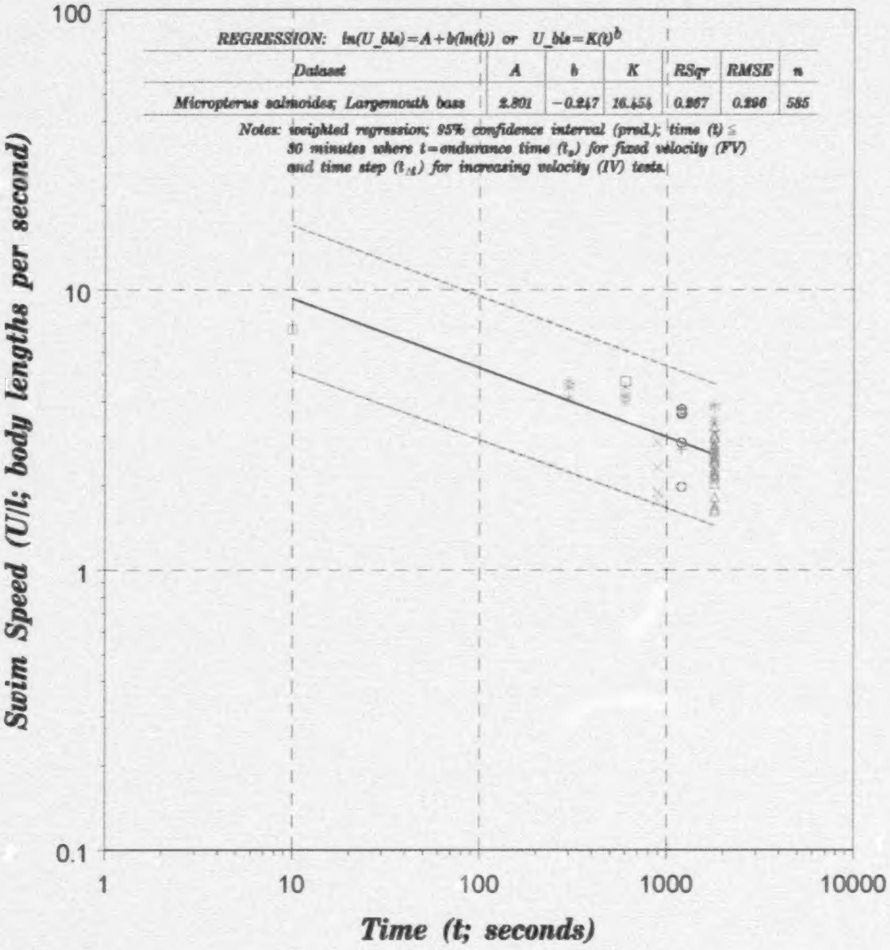


Figure B-066. Processed data for Micropterus salmoides *(Largemouth Bass): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Dalberg et al. (1968); red triangles are data from Beamish (1970); green stars are data from Farlinger and Beamish (1977); black circles are data from Kolok (1991; turquoise diamonds are data from Kolok (1992a); blue crosses are data from Kolok (1992b); red x's are data from Cooke et al. (2001); black squares are data from Leavy and Bonner (2009).*

Table B-066. Data summary. Fish count 585, record count 58.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.128	0.048	0.032	0.26	0.228	18
T (C)	18.2	7.9	5	34	29	15
U (m/s)	0.375	0.098	0.2	0.65	0.45	54
t_e (s)	•	•	•	•	•	0
$t_{\Delta t}$ (s)	1114	474	10	1800	1790	6

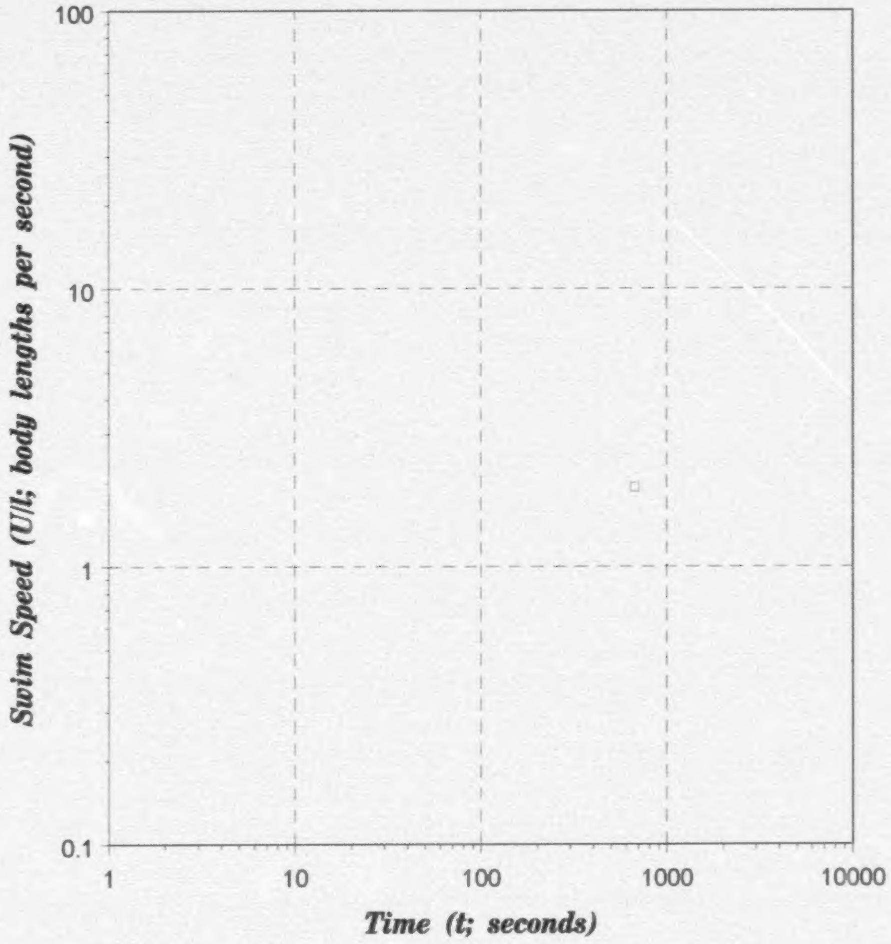


Figure B-067. Processed data for Morone americana *(White Perch): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from from Mellas and Haynes (1985).*

Table B-067. Data summary. Fish count 100, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.264	0	0.264	0.264	0	1
T (C)	21.5	0	21.5	21.5	0	1
U (m/s)	0.51	0	0.51	0.51	0	1
t_e (s)	670	0	670	670	0	1
$t_{\Delta t}$ (s)	.	.	.	.	.	0

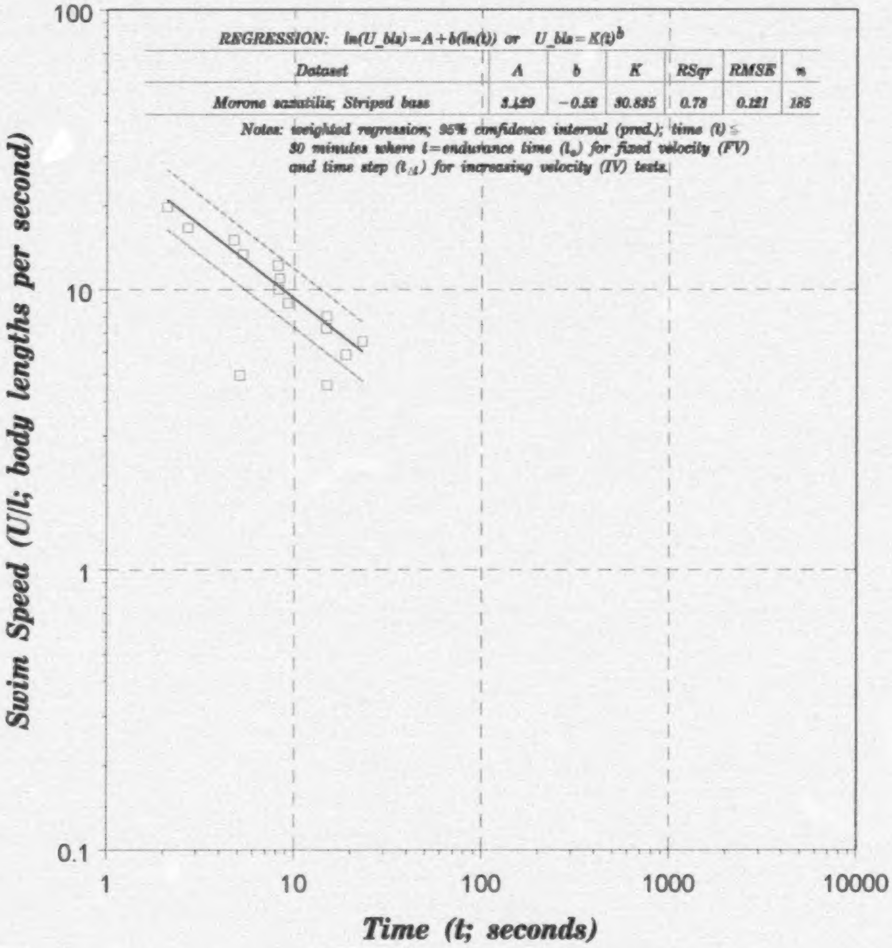


Figure B-068. Processed data for Morone saxatilis *(Striped Bass): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Castro-Santos. (2005).*

Table B-068. Data summary. Fish count 185, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.478	0	0.478	0.478	0	5
T (C)	18.9	0	18.9	18.9	0	1
U (m/s)	4.66	1.209	2.185	9.45	7.265	14
t_e (s)	11	5	2	23	21	14
$t_{\Delta t}$ (s)	.	.	.	.	.	0

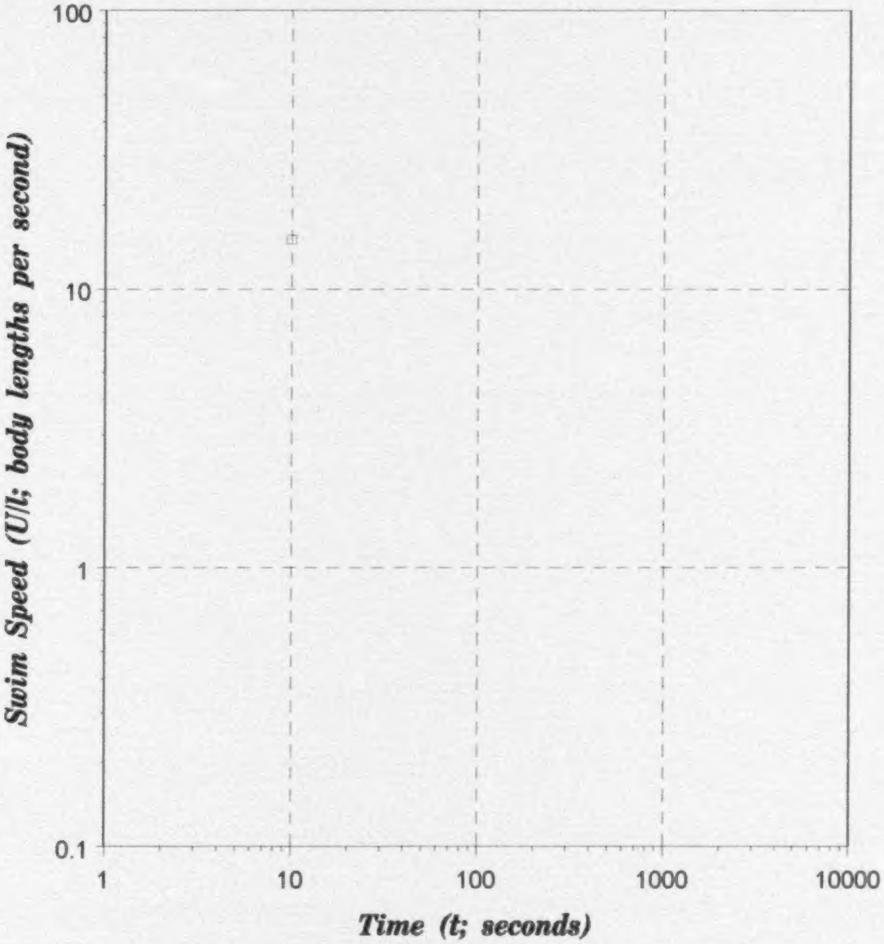


Figure B-069. Processed data for Notropis amabilis *(Texas Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-069. Data summary. Fish count 29, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.42	0	1
T (C)	23.4	0	23.4	23.4	0	1
U (m/s)	0.636	0	0.636	0.636	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

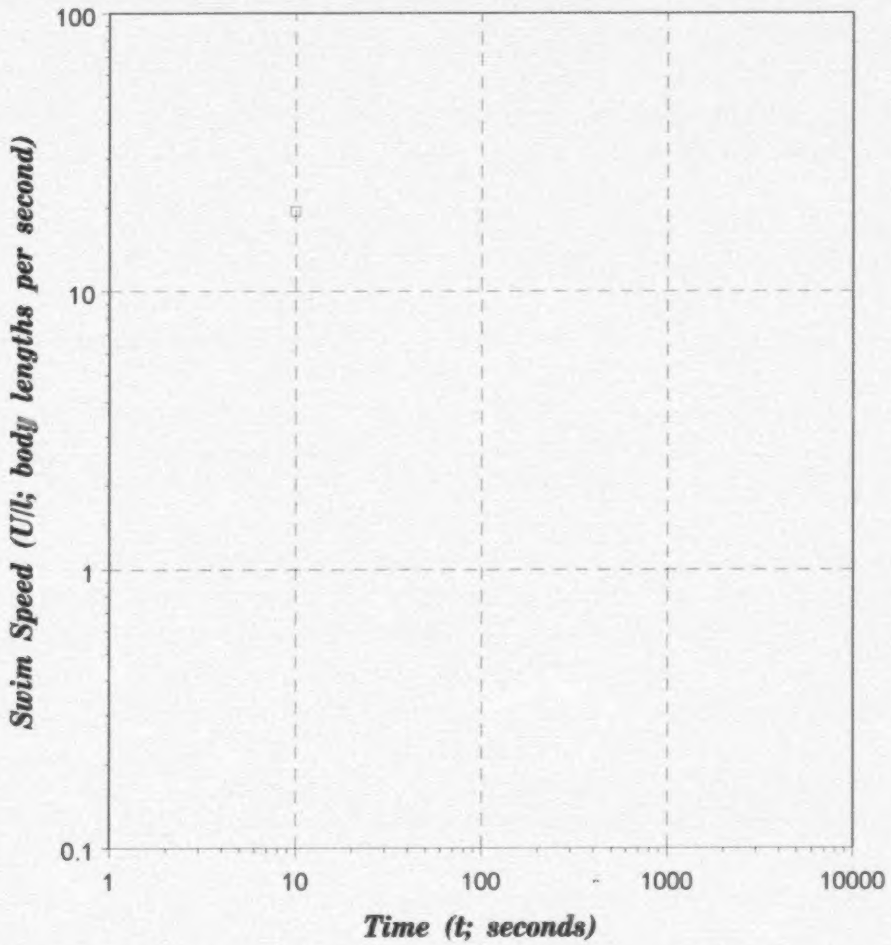


Figure B-070. Processed data for Notropis atherinoides *(Emerald Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-070. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.042	0	1
T (C)	30	0	30	30	0	1
U (m/s)	0.814	0	0.814	0.814	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

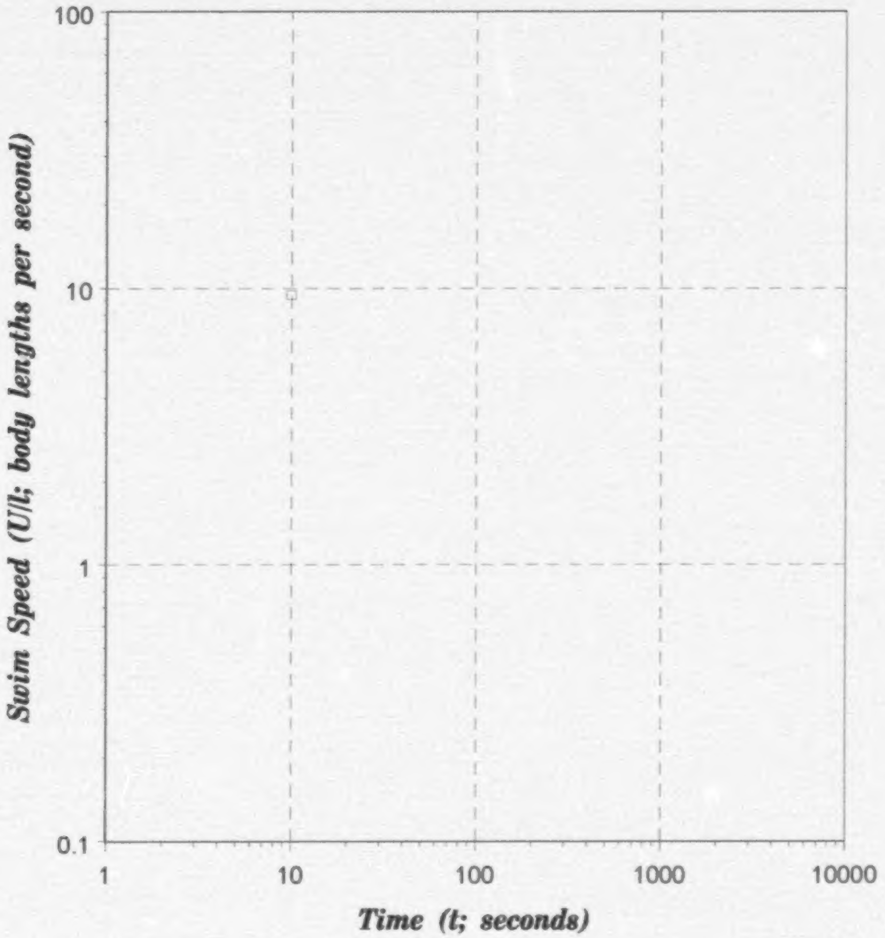


Figure B-071. Processed data for Notropis atrocaudalis *(Blackspot Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-071. Data summary. Fish count 11, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.05	0	0.05	0.05	0	1
T (C)	26.7	0	26.7	26.7	0	1
U (m/s)	0.469	0	0.469	0.469	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

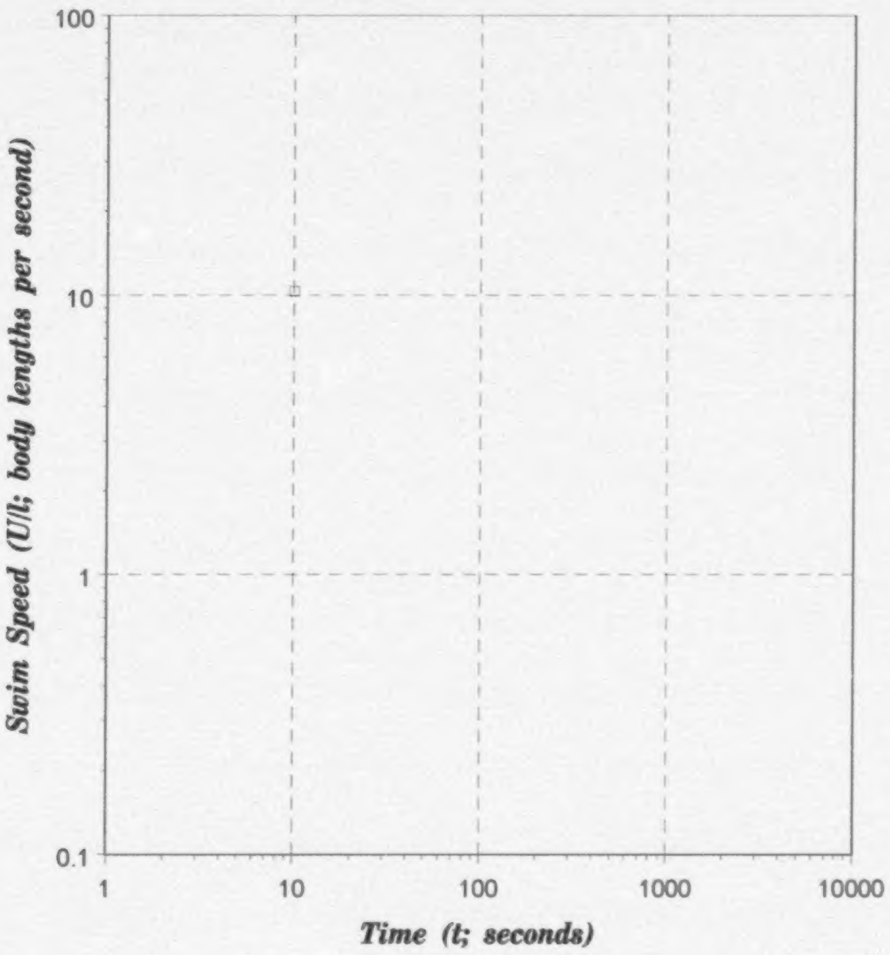


Figure B-072. Processed data for Notropis bairdi *(Red River Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-072. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.044	0	0.044	0.044	0	1
T (C)	25.8	0	25.8	25.8	0	1
U (m/s)	0.456	0	0.456	0.456	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

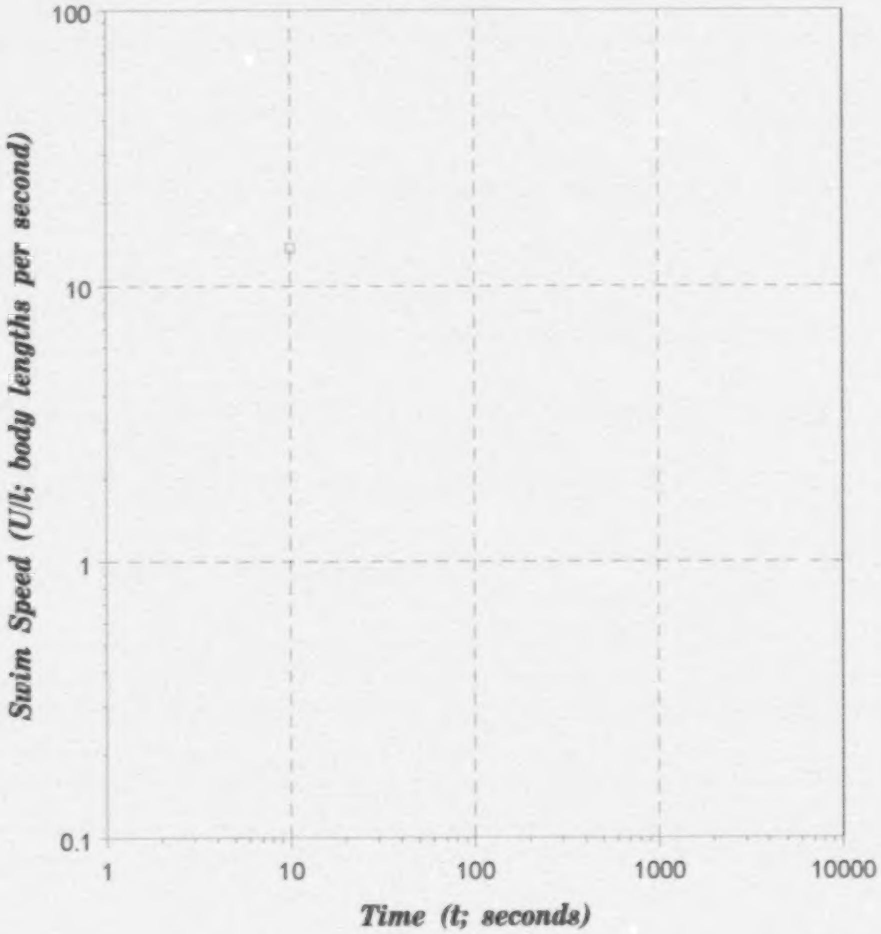


Figure B-073. Processed data for Notropis buccula *(Smalleye Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-073. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	32.9	0	32.9	32.9	0	1
U (m/s)	0.497	0	0.497	0.497	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

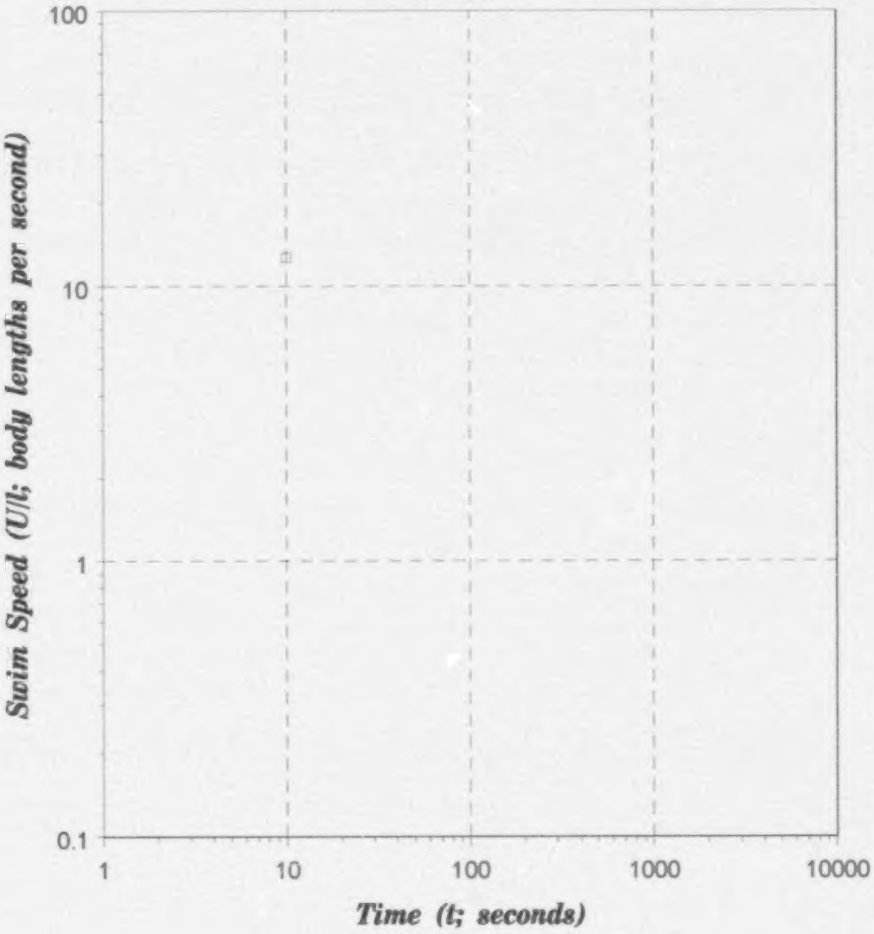


Figure B-074. Processed data for Notropis buchanani *(Ghost Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner. (2009).*

Table B-074. Data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	25.9	0	25.9	25.9	0	1
U (m/s)	0.447	0	0.447	0.447	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

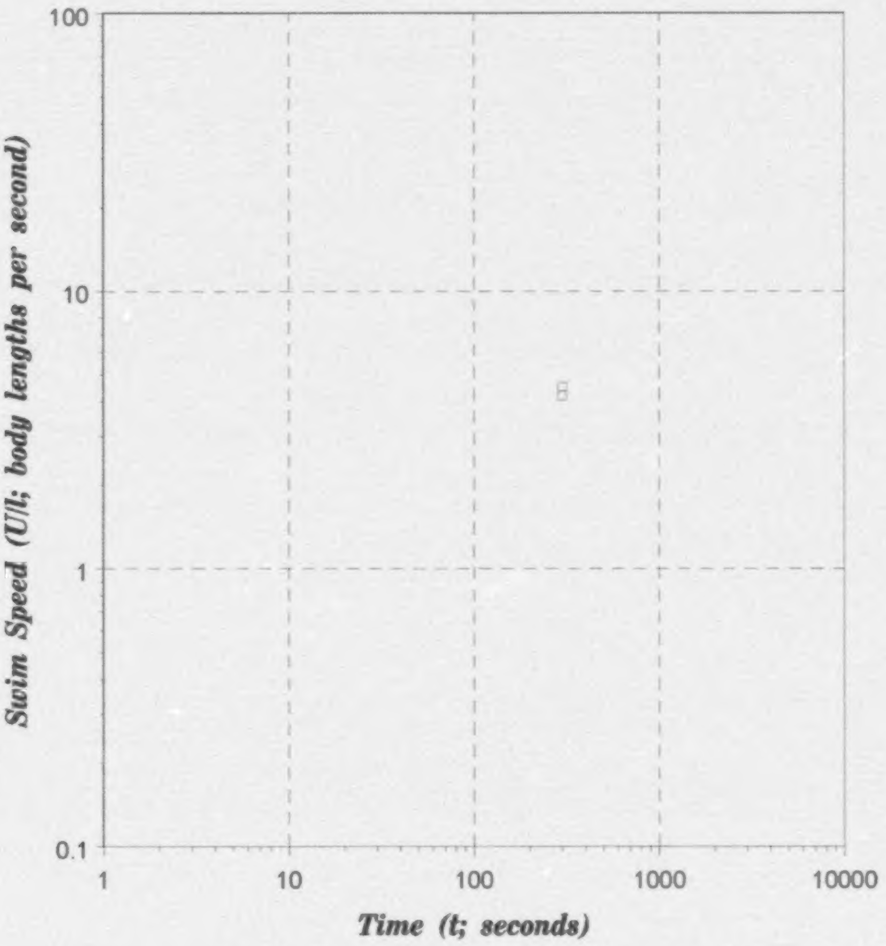


Figure B-075. Processed data for Notropis hudsonius *(Spottail Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Goertzen (2011).*

Table B-075. Data summary. Fish count 32, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0.002	0.049	0.052	0.003	2
T (C)	12	0	12	12	0	1
U (m/s)	0.22	0.001	0.219	0.221	0.002	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

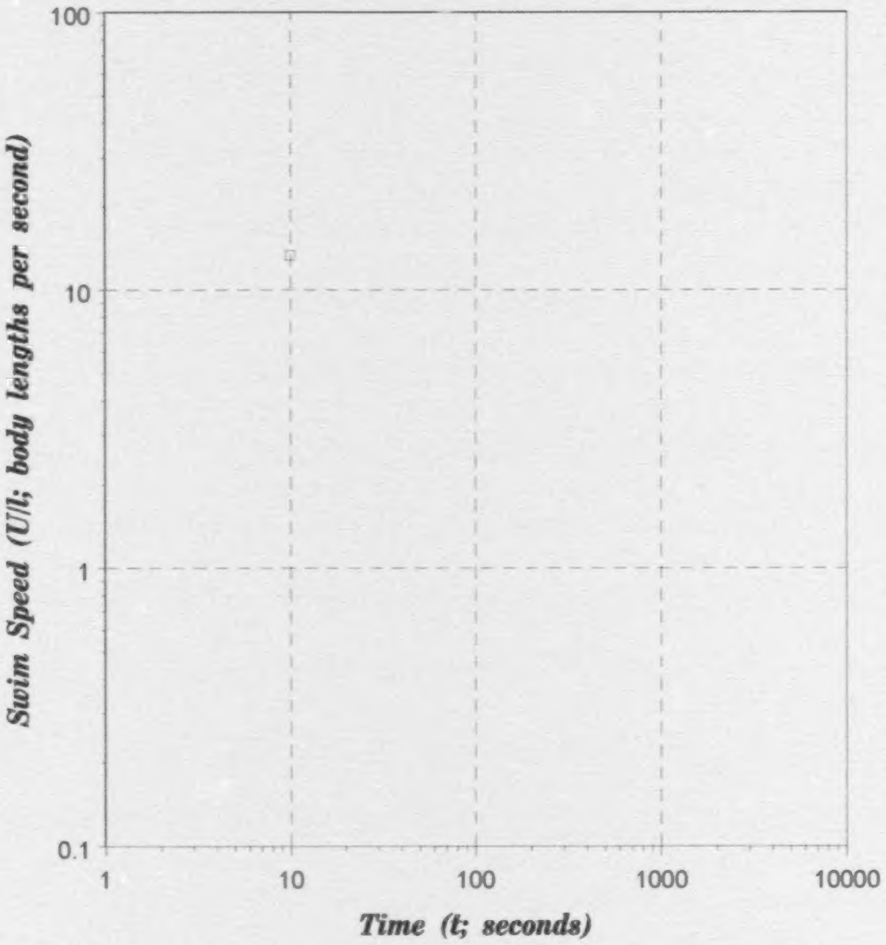


Figure B-076. Processed data for Notropis oxyrhynchus *(Sharpnose Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-076. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0	0.04	0.04	0	1
T (C)	32.9	0	32.9	32.9	0	1
U (m/s)	0.534	0	0.534	0.534	0	1
t_c (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

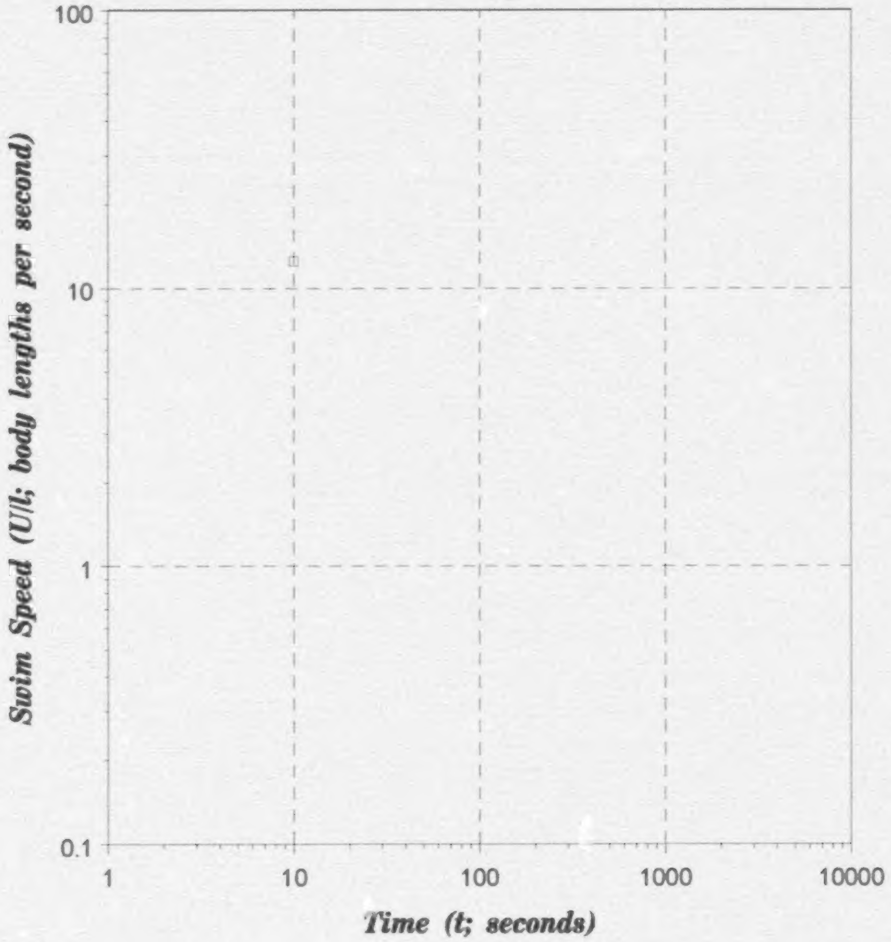


Figure B-077. Processed data for Notropis sabinae *(Sabine Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-077. Data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.038	0	0.038	0.038	0	1
T (C)	27.4	0	27.4	27.4	0	1
U (m/s)	0.469	0	0.469	0.469	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

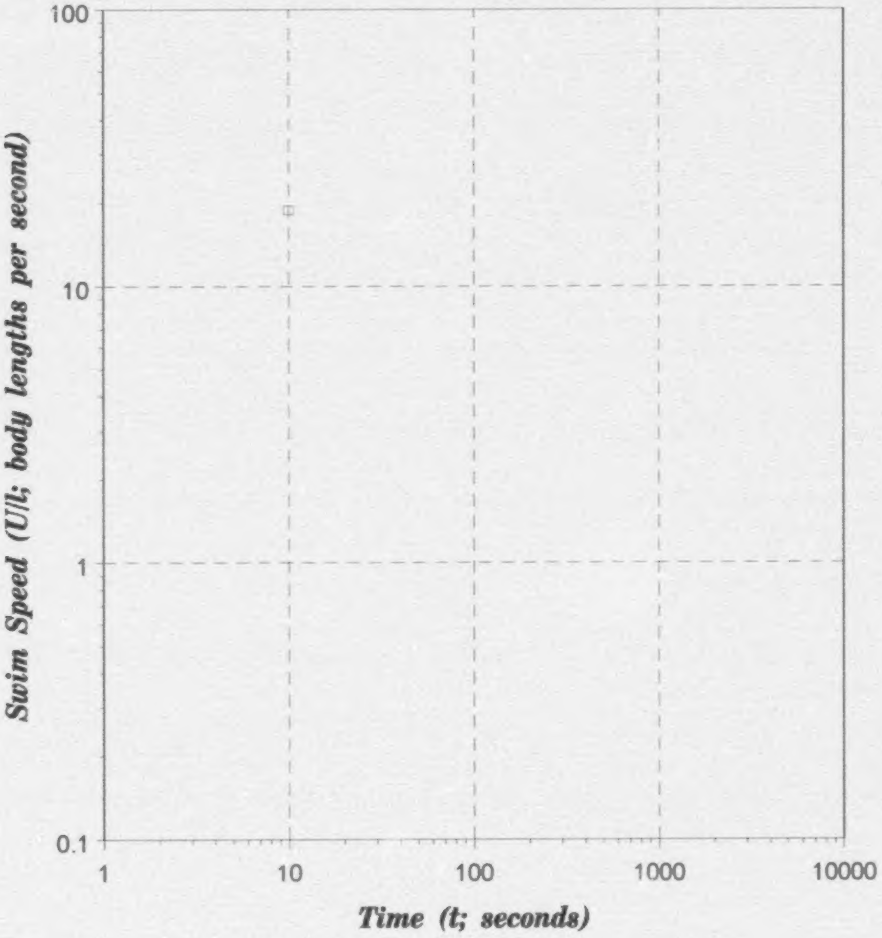


Figure B-078. Processed data for Notropis shumardi *(Silverband Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-078. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.042	0	1
T (C)	30.5	0	30.5	30.5	0	1
U (m/s)	0.794	0	0.794	0.794	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

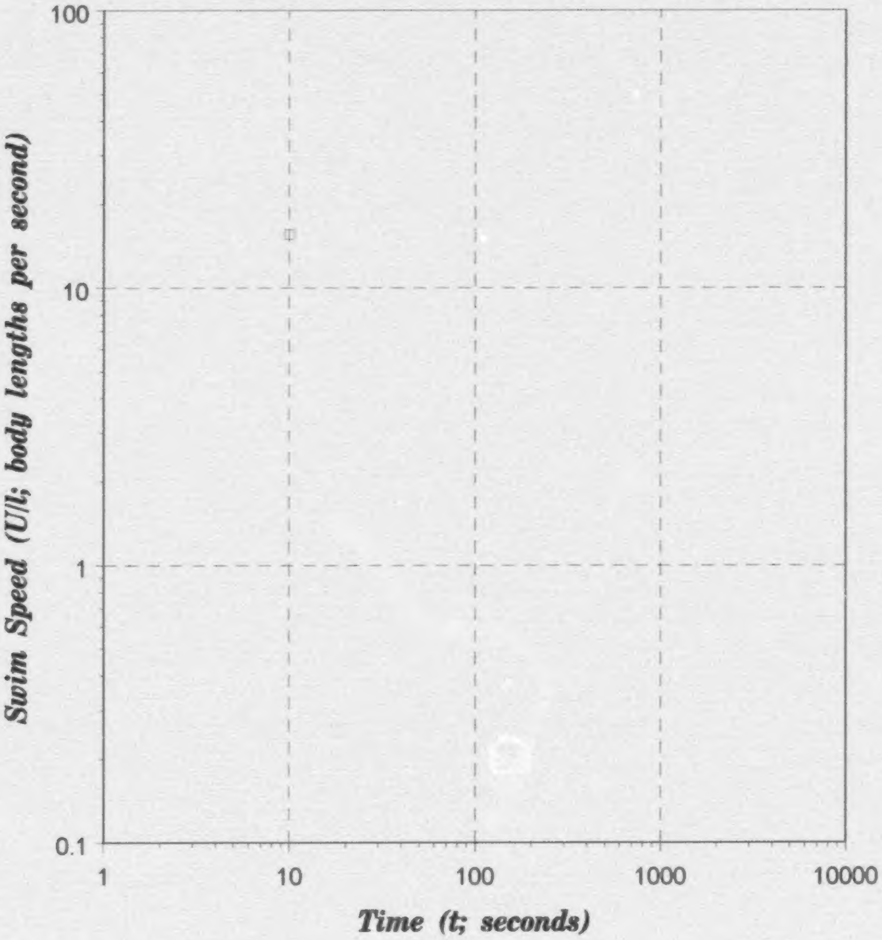


Figure B-079. Processed data for Notropis stramineus *(Sand Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-079. Data summary. Fish count 18, record count 1.

Variables	**Mean**	**SD**	**Min**	**Max**	**Range**	**N**
l (m)	0.043	0	0.043	0.043	0	1
T (C)	28.4	0	28.4	28.4	0	1
U (m/s)	0.665	0	0.665	0.665	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

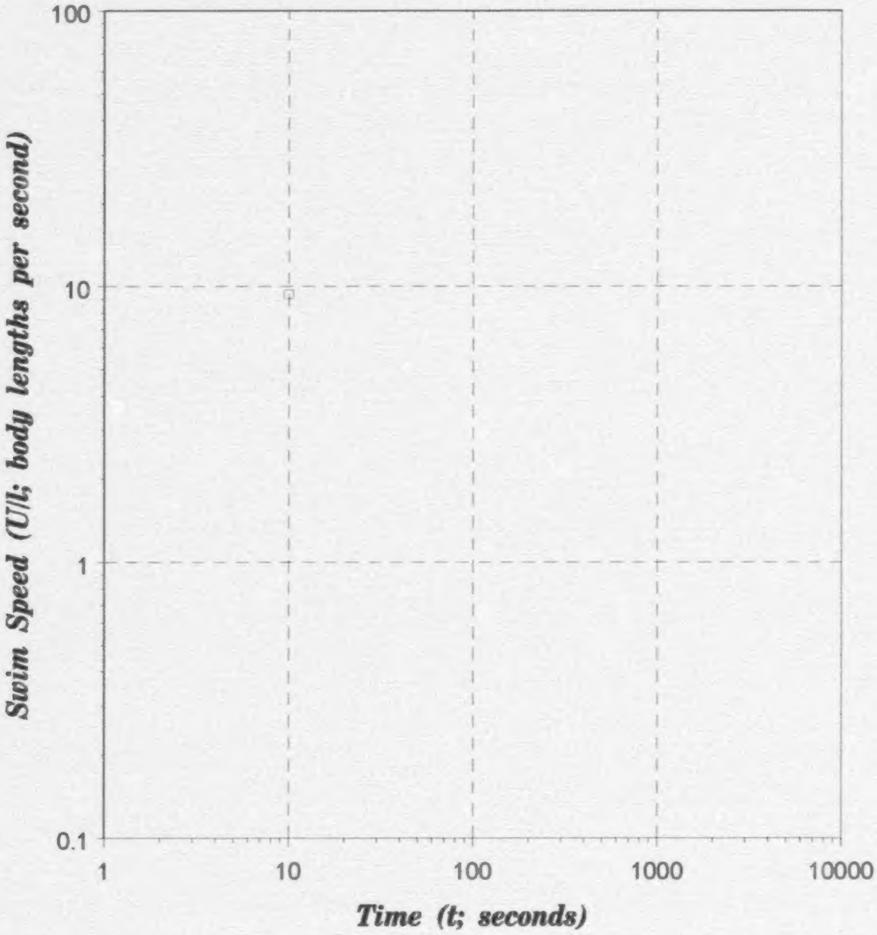
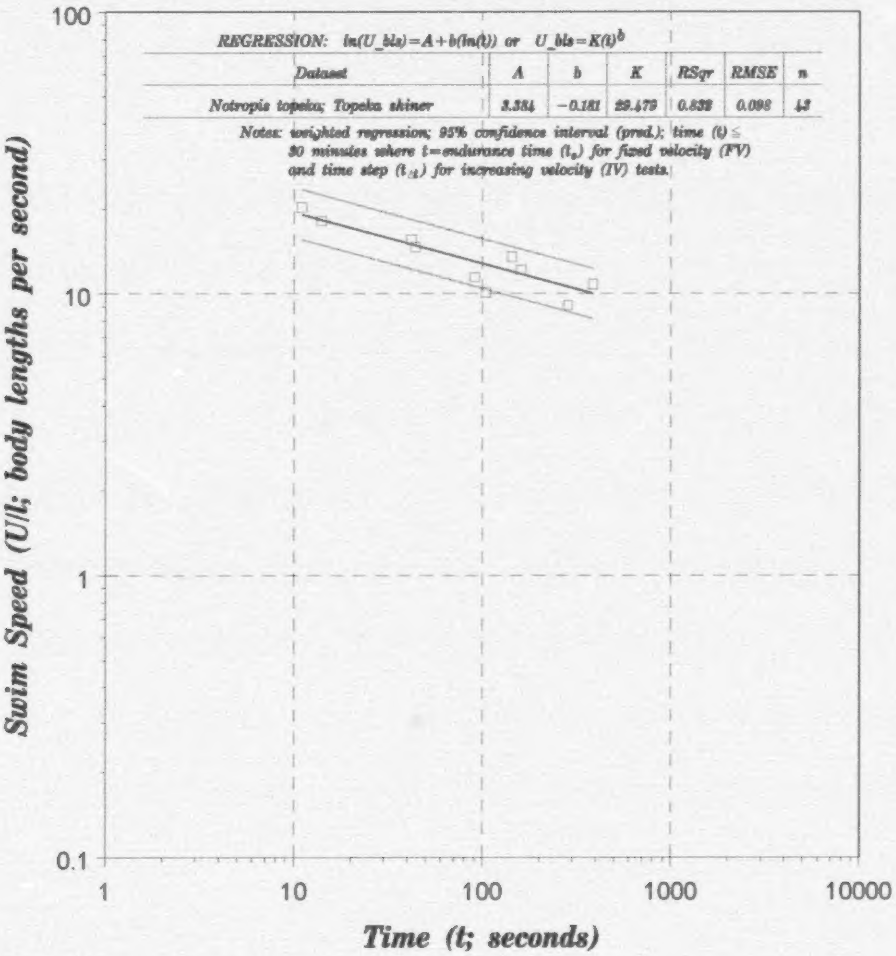


Figure B-080. Processed data for Notropis texanus *(Weed Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-080. Data summary. Fish count 7, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.041	0	0.041	0.041	0	1
T (C)	27.3	0	27.3	27.3	0	1
U (m/s)	0.387	0	0.387	0.387	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1



REGRESSION: $\ln(U\_bls)=A+b(\ln(t))$ or $U\_bls=K(t)^b$

Dataset	A	b	K	RSqr	RMSE	n
Notropis topeka; Topeka shiner	3.384	−0.181	29.479	0.838	0.098	43

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t=endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure B-081. Processed data for Notropis topeka *(Topeka Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Adams et al. (2000).*

Table B-081. Data summary. Fish count 43, record count 10.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0.005	0.037	0.05	0.013	2
T (C)	20	0	20	20	0	1
U (m/s)	0.559	0.113	0.4	0.75	0.35	8
t_e (s)	118	124	11	385	374	10
$t_{\Delta t}$ (s)	.	.	.	.	.	0

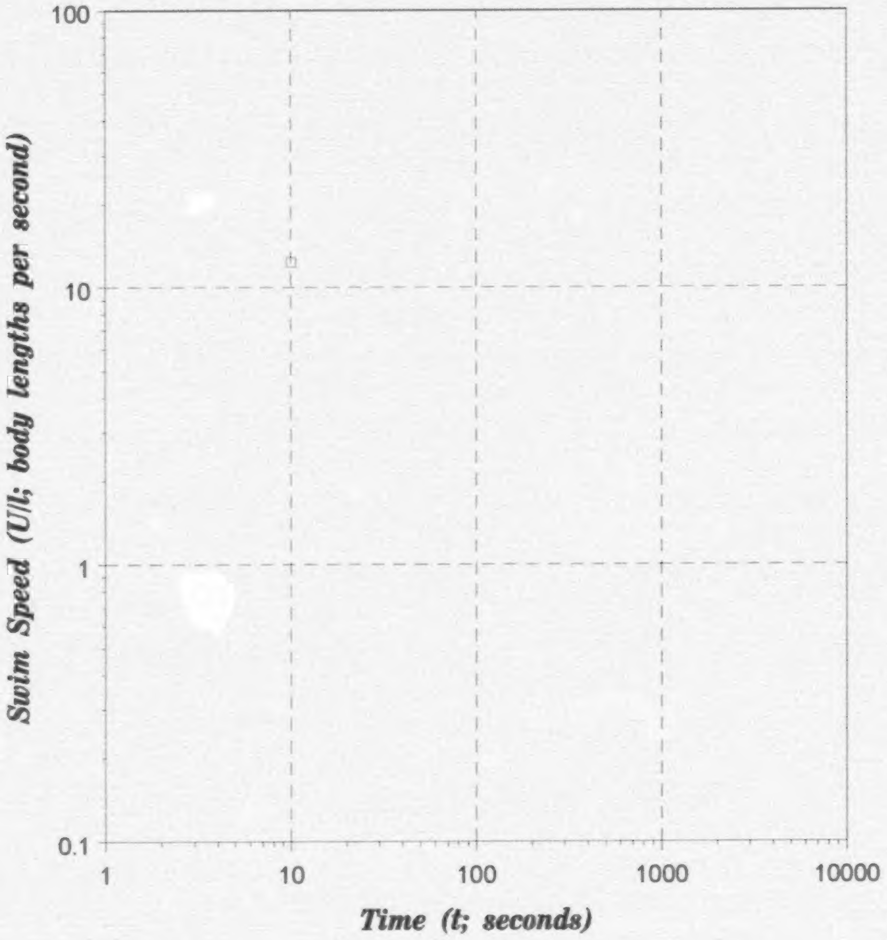


Figure B-082. Processed data for Notropis volucellus *(Mimic Shiner):time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-082. Data summary. Fish count 15, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	27.8	0	27.8	27.8	0	1
U (m/s)	0.436	0	0.436	0.436	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

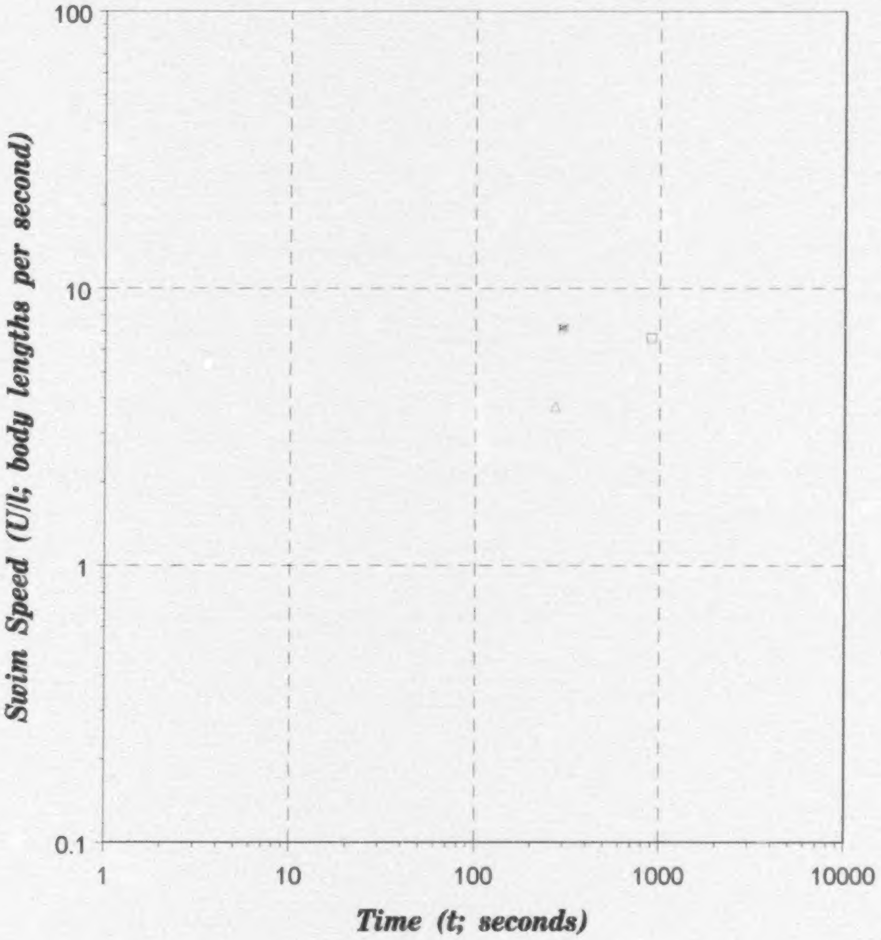


Figure B-083 Processed data for Oncorhynchus clarki *(Cutthroat Trout): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Hawkins and Quinn (1996); red triangles are data from Zale et al. (2005); green stars are data from Aedo et al. (2009).*

Table B-083. Data summary. Fish count 161, record count 49.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.099	0.055	0.038	0.24	0.202	7
T (C)	17.8	2	13	19	6	3
U (m/s)	0.578	0.148	0.277	0.9	0.623	7
t_e (s)	272	0	272	272	0	1
$t_{\Delta t}$ (s)	734	269	300	900	600	2

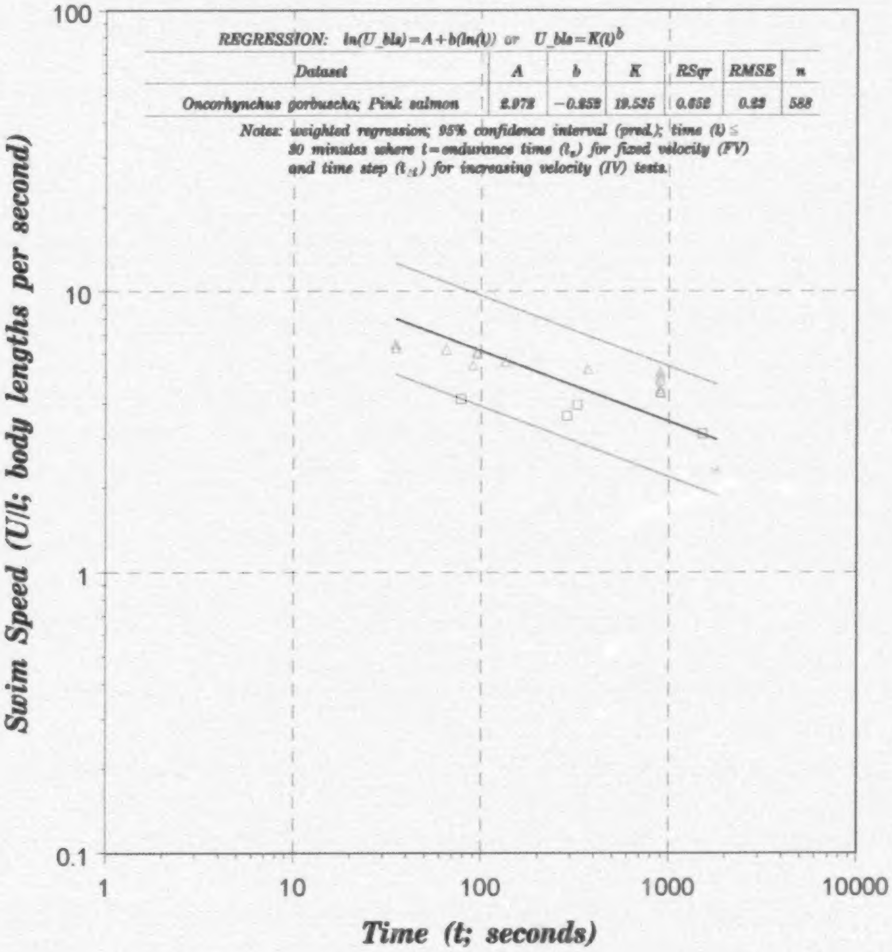
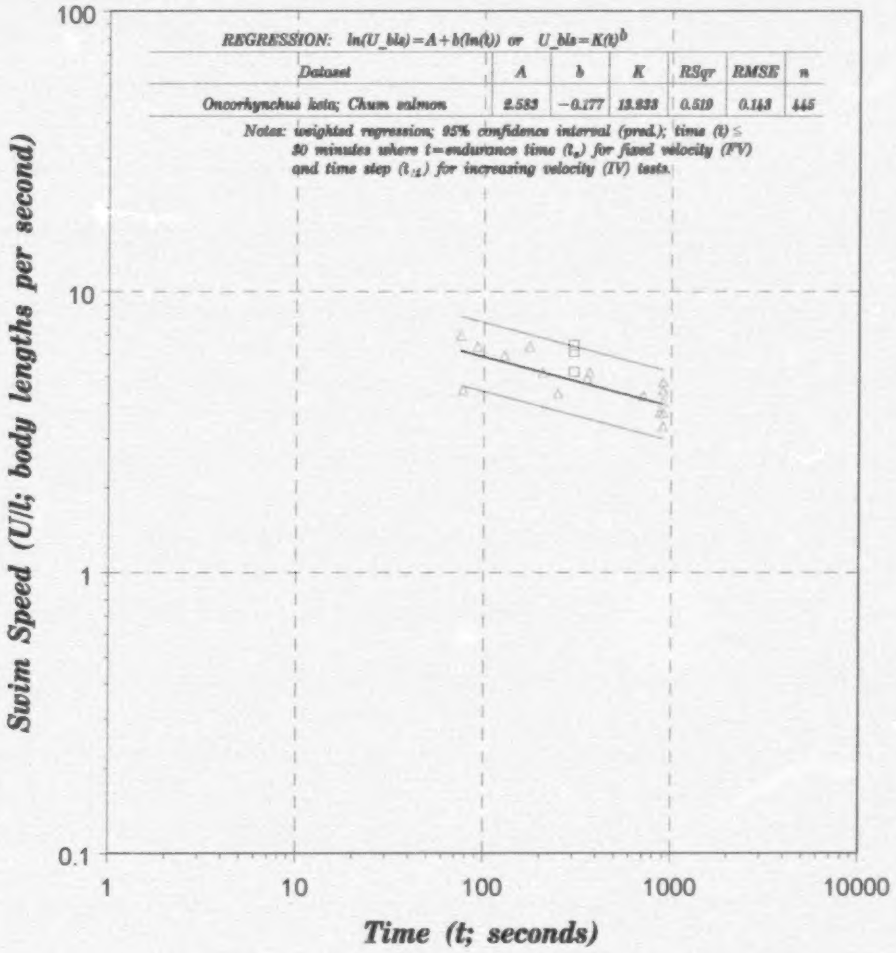


Figure B-084. Processed data for Oncorhynchus gorbuscha *(Pink Salmon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Brett (1982); red triangles are data from Smith and Carpenter (1987); green stars are data from Williams and Brett (1987).*

Table B-084. Data summary. Fish count 588, record count 19.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.188	0.217	0.031	0.574	0.543	8
T (C)	9	3.8	4	20	16	5
U (m/s)	0.518	0.508	0.136	2.38	2.244	13
t_e (s)	300	378	35	1508	1473	11
$t_{\Delta t}$ (s)	1372	450	900	1800	900	2



REGRESSION: $\ln(U\_bls) = A + b(\ln(t))$ or $U\_bls = K(t)^b$

Dataset	A	b	K	RSqr	RMSE	n
Oncorhynchus keta; Chum salmon	2.583	−0.177	13.233	0.519	0.143	445

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 20 minutes where t=endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure B-085. Processed data for Oncorhynchus keta *(Chum Salmon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Houston (1959); red triangles are data from Smith and Carpenter (1987).*

Table B-085. Data summary. Fish count 445, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.039	0.002	0.038	0.048	0.01	7
T (C)	7.1	2.5	4	10	6	3
U (m/s)	0.177	0.042	0.126	0.291	0.165	15
t_e (s)	436	325	75	900	825	12
$t_{\Delta t}$ (s)	851	165	300	900	600	2

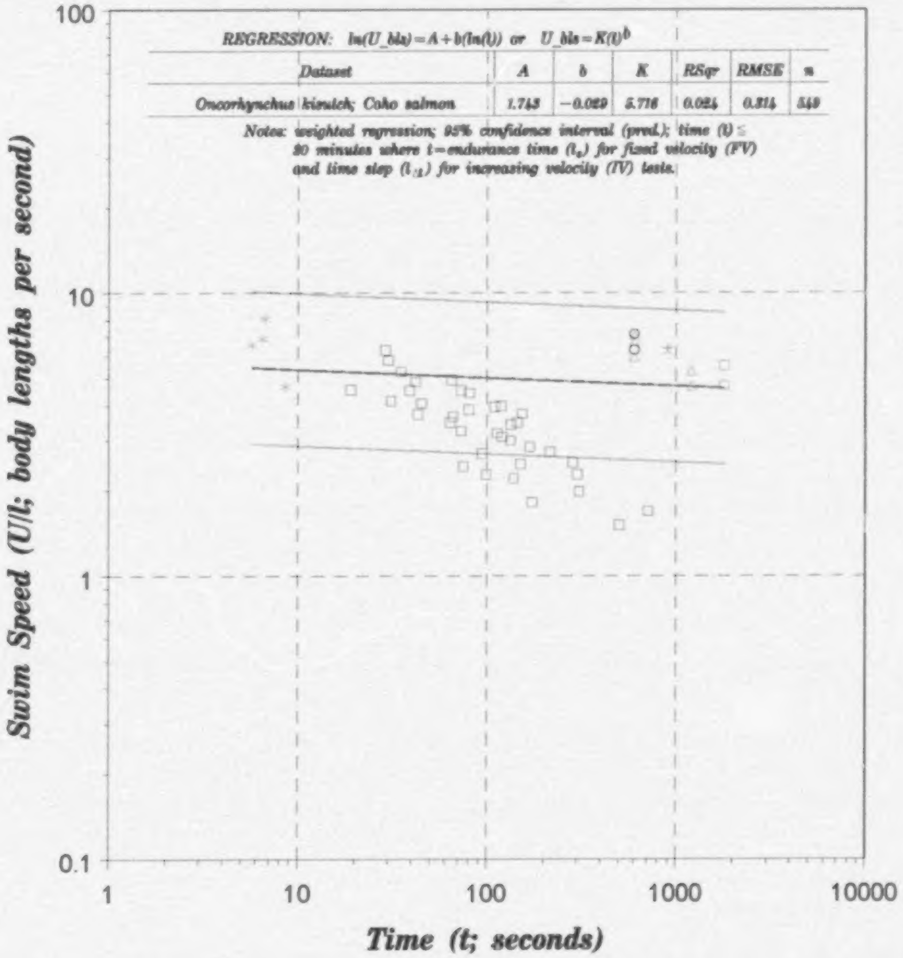


Figure B-086. Processed data for Oncorhynchus kisutch *(Coho Salmon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Paulik and DeLacy (1957); red triangles are data from Davis et al. (1963); green stars are data from Weaver (1963); black circles are data from Dahlberg et al. (1968); turquoise diamonds are data from Smith and Carpenter (1987); blue crosses are data from MacKinnon and Farrell (1992); red x's are data from Nikl and Farrell (1993); green squares are data from Brauner et al. (1994b).*

Table B-086. Data summary. Fish count 549, record count 60.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.218	0.244	0.034	0.75	0.716	41
T (C)	11.9	4.6	7	20.1	13.1	13
U (m/s)	1.024	1.166	0.131	4.059	3.928	31
t_e (s)	142	145	6	714	708	45
$t_{\Delta t}$ (s)	939	336	600	1800	1200	4

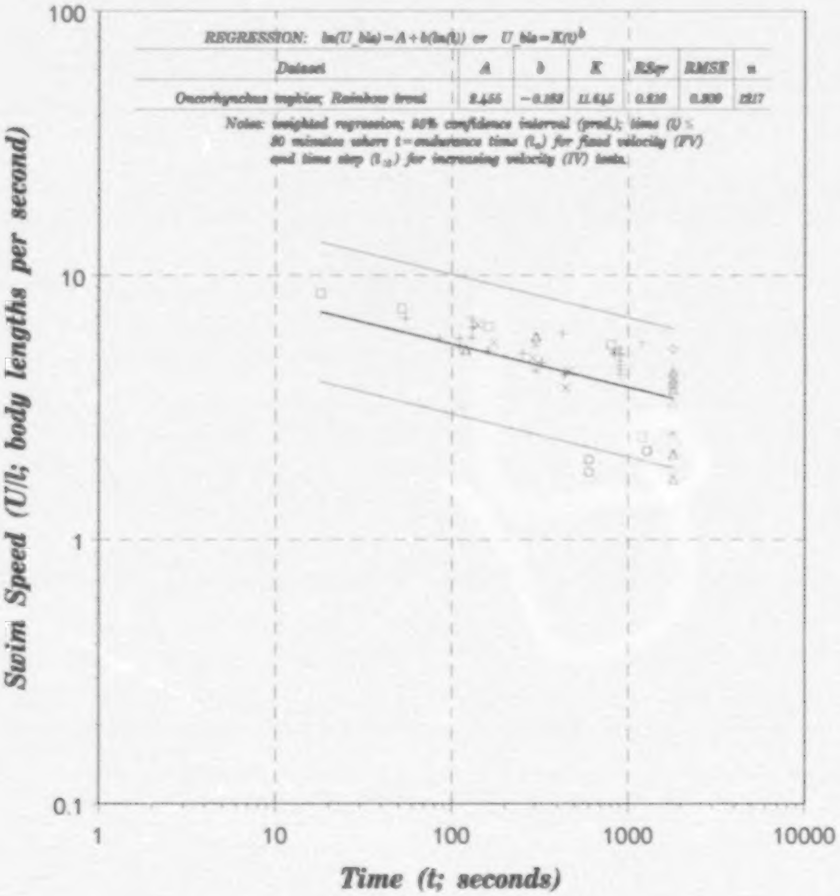


Figure B-087. Processed data for Oncorhynchus mykiss *(Rainbow Trout): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Tsukamoto (1975); red triangles are data from Beamish (1980); green stards are data from Daxboeck (1982); black circles are data form Mellas and Haynes (1985); turquoise diamonds are data from Duthie and Hughes (1987); blue crosses area data from Smith and Carpenter (1987); red x's are data from Farrell et al. (1990); green squares are data from Farrell et al. (1991); black triangles are data from Gamperl et al. (1991), tuquoise stars are data from Pearson and Stevens (1991) ,blue circles are data from Gallaugher et al. (1992); red diamonds are data from Nikl and Farrell (1993), dark green crosses data are from Johansen et al. (1994); black x's are data from Mitton and McDonald (1994); turquoise squares are data from Anderson et al. (1997); blue triangles are data from Jain et al. (1997); red stars are data from Peake et al. (1997a); green crosses are data from McDonald et al.(1998.*

Table B-087. Data summary. Fish count 1217, record count 60.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.116	0.116	0.024	0.41	0.398	44
T (C)	11.8	3.5	6	18.5	12.5	17
U (m/s)	0.408	0.315	0.11	1.47	1.36	42
t_e (s)	538	417	18	1278	1260	22
$t_{\Delta t}$ (s)	763	544	120	1800	1680	6

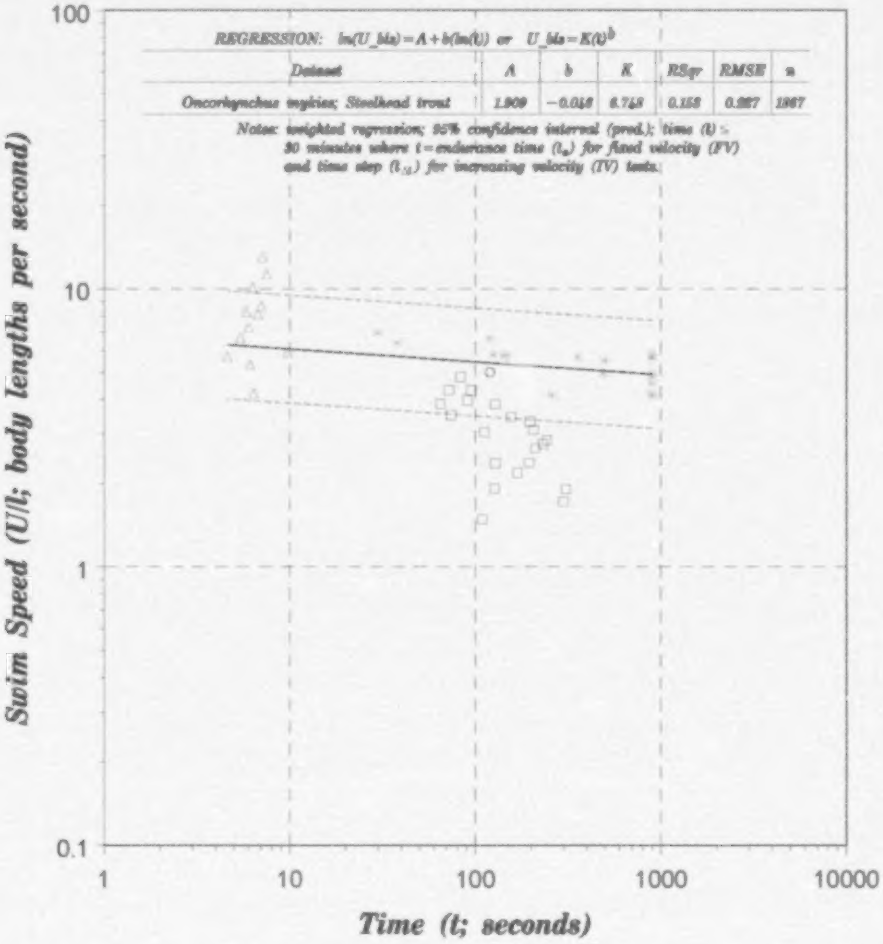


Figure B-088. Processed data for Oncorhynchus mykiss *(Steelhead Trout): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Paulik and DeLacy (1957); red triangles are data from Weaver (1963); green crosses are data from Smith and Carpenter (1987); black circles are data from Webb (1993); turquoise diamonds are data from Hawkins and Quinn (1996).*

Table B-088. Data summary. Fish count 1867, record count 54.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.45	0.271	0.028	0.82	0.792	26
T (C)	16.4	4.1	7	19	12	6
U (m/s)	2.751	1.772	0.115	6.406	6.291	31
t_e (s)	89	223	5	900	895	42
$t_{\Delta t}$ (s)	872	147	120	900	780	2

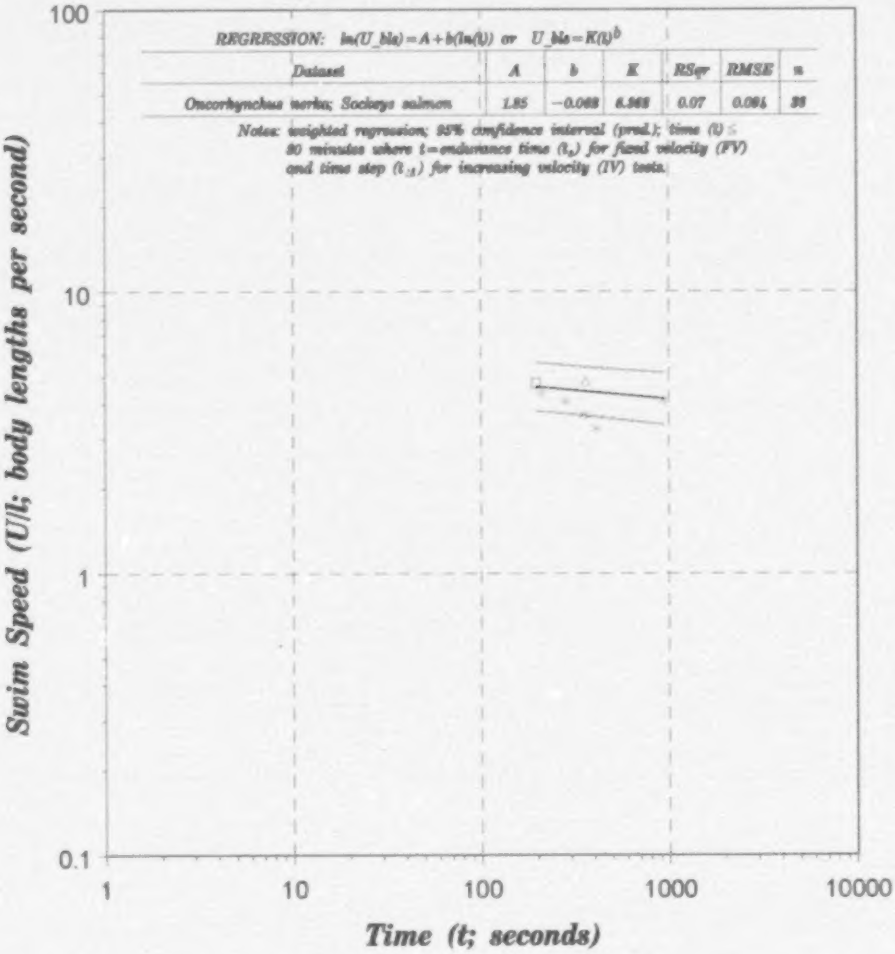


Figure B-089. Processed data for Oncorhynchus nerka *(Sockeye Salmon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Brett (1964); red triangles are data from Brett (1967); green stars are data from Brett (1982).*

Table B-089. Data summary. Fish count 36, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.308	0.2	0.138	0.621	0.483	6
T (C)	15.1	3.1	18	18	8	3
U (m/s)	1.301	0.739	2.268	2.268	1.606	6
t_e (s)	353	193	942	942	746	6
$t_{\Delta t}$ (s)	.	.	.	.	.	0

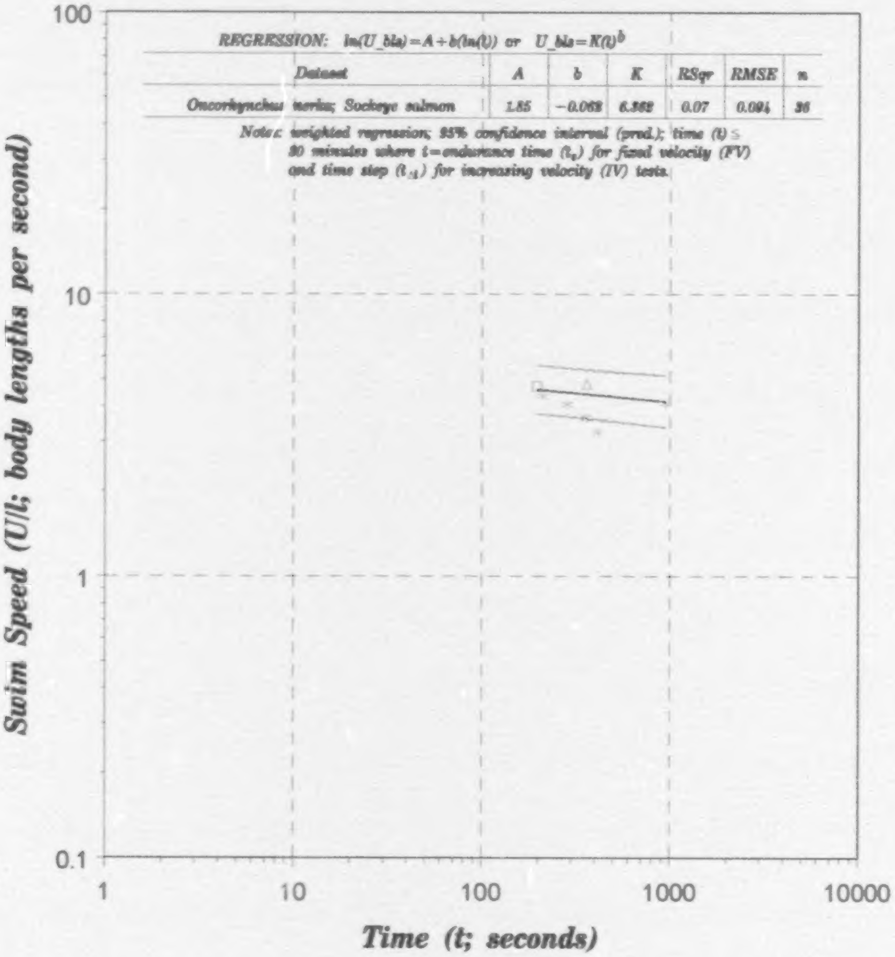


Figure B-090. Processed data for Oncorhynchus tshawytscha *(Chinook Salmon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Weaver (1963); red triangles are data from Ferrell and Steffensen (1987); green stars are data from Smith and Carpenter (1987); black circles are data from Brauner et al. (1993); turquoise diamonds are data from Nikl and Farrell (1993); blue crosses are data from Thorarensen (1993); red x's are data from Muir et al. (1994); green squares are data from Adams et al. (1998).*

Table B-090. Data summary. Fish count 1214, record count 46.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.325	0.303	0.038	0.927	0.889	16
T (C)	12.9	6	3.1	19	15.9	15
U (m/s)	2.047	1.999	0.14	6.223	6.083	38
t_e (s)	90	188	5	900	896	25
$t_{\Delta t}$ (s)	968	233	900	1800	900	3

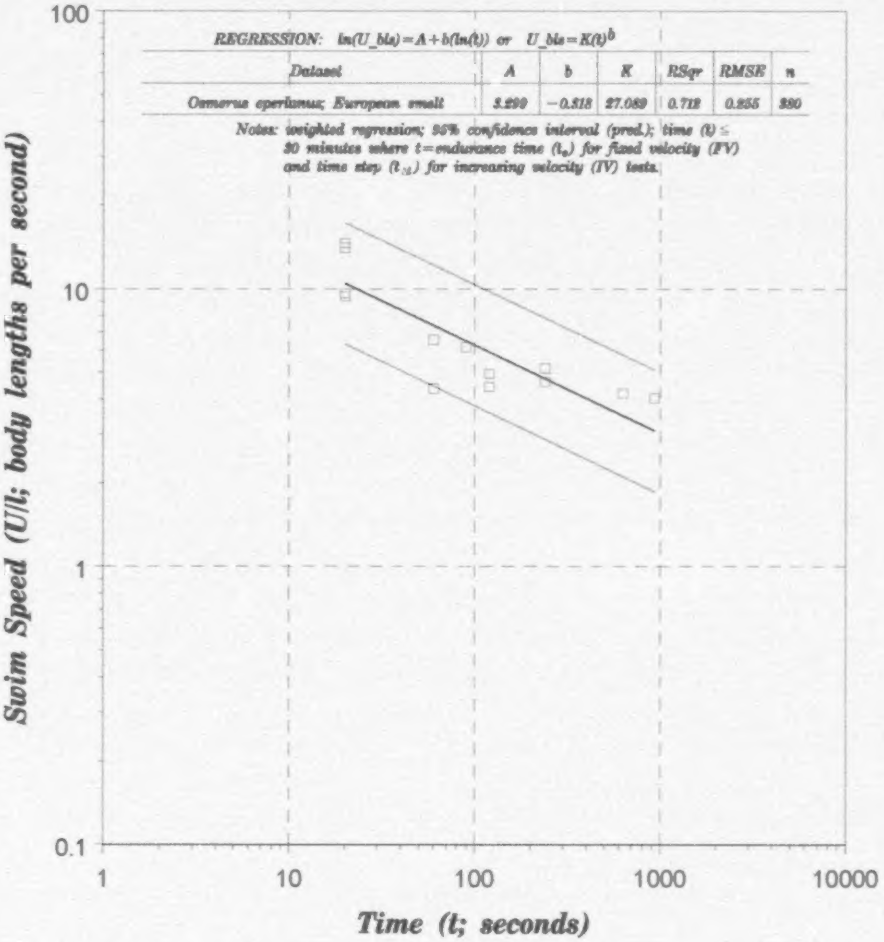


Figure B-091. Processed data for Osmerus eperlanus *(European Smelt): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Clough et al. (2003).*

Table B-091. Data summary. Fish count 380, record count 13.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.098	0.018	0.074	0.12	0.046	11
T (C)	12	3.5	6	17.4	11.4	11
U (m/s)	0.787	0.324	0.375	1.154	0.779	8
t_e (s)	268	293	60	930	870	6
$t_{\Delta t}$ (s)	20	0	20	20	0	1

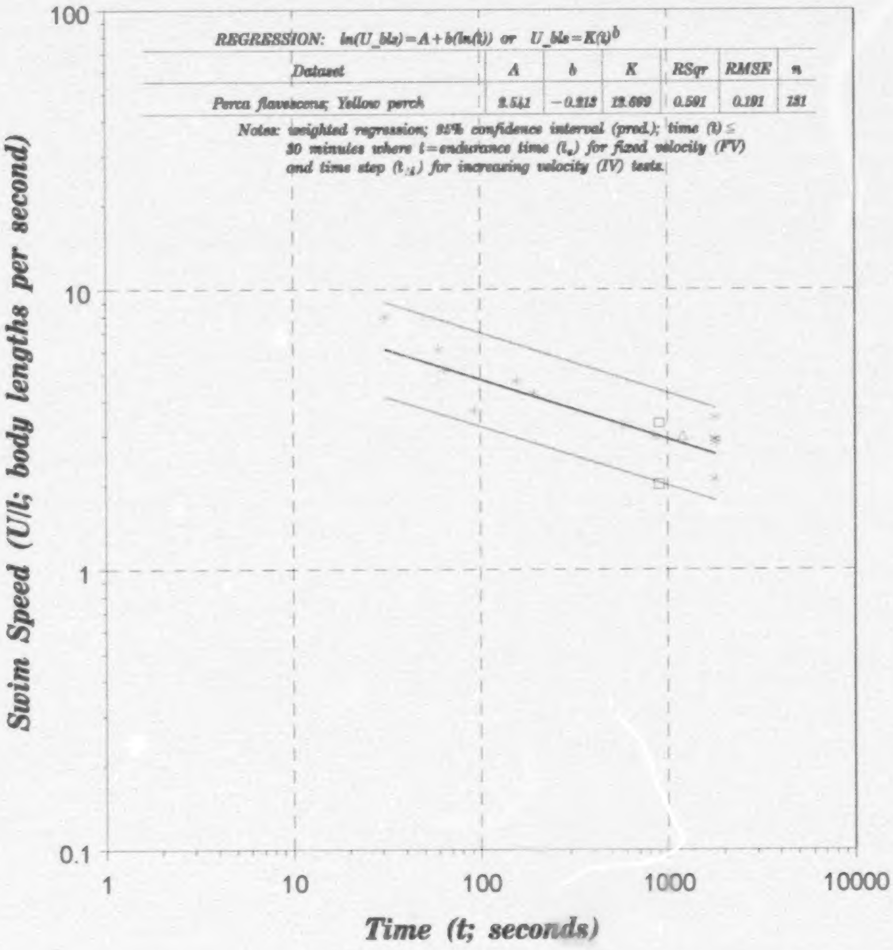


Figure B-092. Processed data for Perca flavescens *(Yellow Perch): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Otto and O'Hare-Rice (1974); red triangles are data from McDonald et al. (1991); green stars are data from Taylor et al. (2004).*

Table B-092. Data summary. Fish count 131, record count 17.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.103	0.019	0.05	0.151	0.101	16
T (C)	18.9	4	10	21	11	4
U (m/s)	0.342	0.077	0.18	0.427	0.247	9
t_e (s)	300	257	31	854	823	8
$t_{\Delta t}$ (s)	1292	433	900	1800	900	3

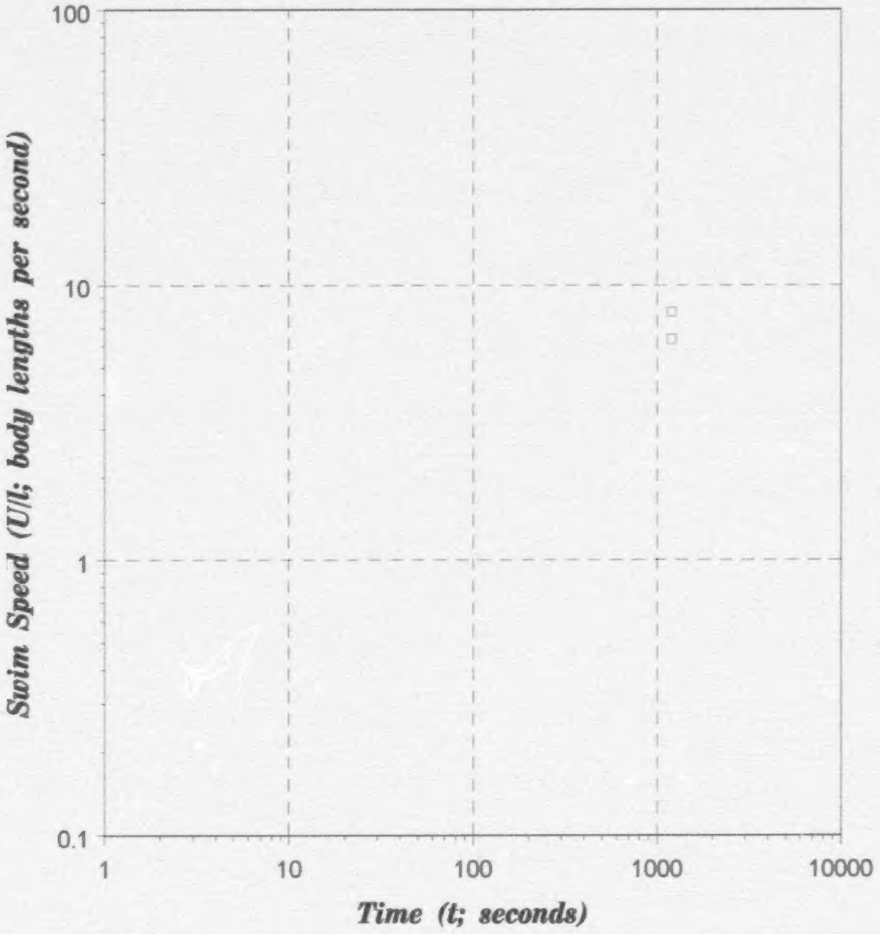


Figure B-093. Processed data for Perca fluviatilis *(European Perch): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Tudorache et al. (2008).*

Table B-093. Data summary. Fish count 16, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.14	0.04	0.101	0.178	0.077	2
T (C)	15	0	15	15	0	1
U (m/s)	0.968	0.168	0.806	1.13	0.325	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

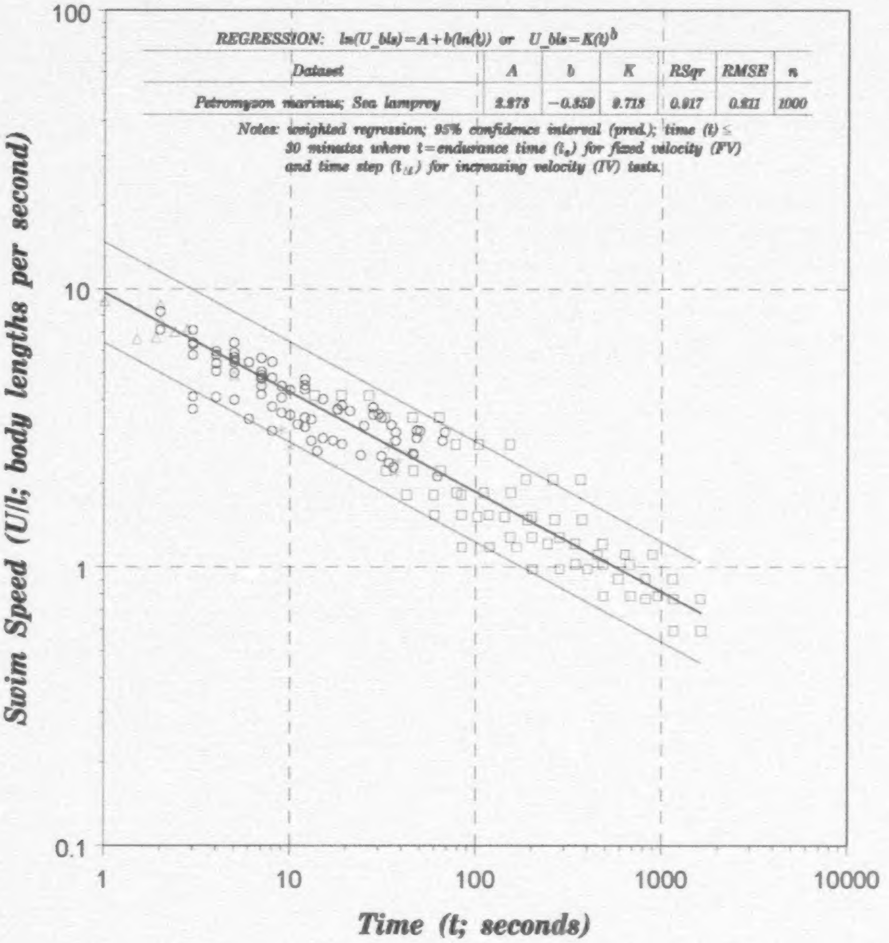


Figure B-094. Processed data for Petromyzon marinus *(Sea Lamprey): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Beamish (1974); red triangles are data from Hanson (1980); green stars are data from Bergstedt et al. (1981); black circles are data from McAuley (1996).*

Table B-094. Data summary. Fish count 1000, record count 151.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.392	0.124	0.145	0.59	0.445	65
T (C)	12.4	5.1	5	23	18	55
U (m/s)	1.265	1.11	0.3	3.961	3.661	89
t_e (s)	216	343	1	1635	1634	99
$t_{\Delta t}$ (s)	.	.	.	.	.	0

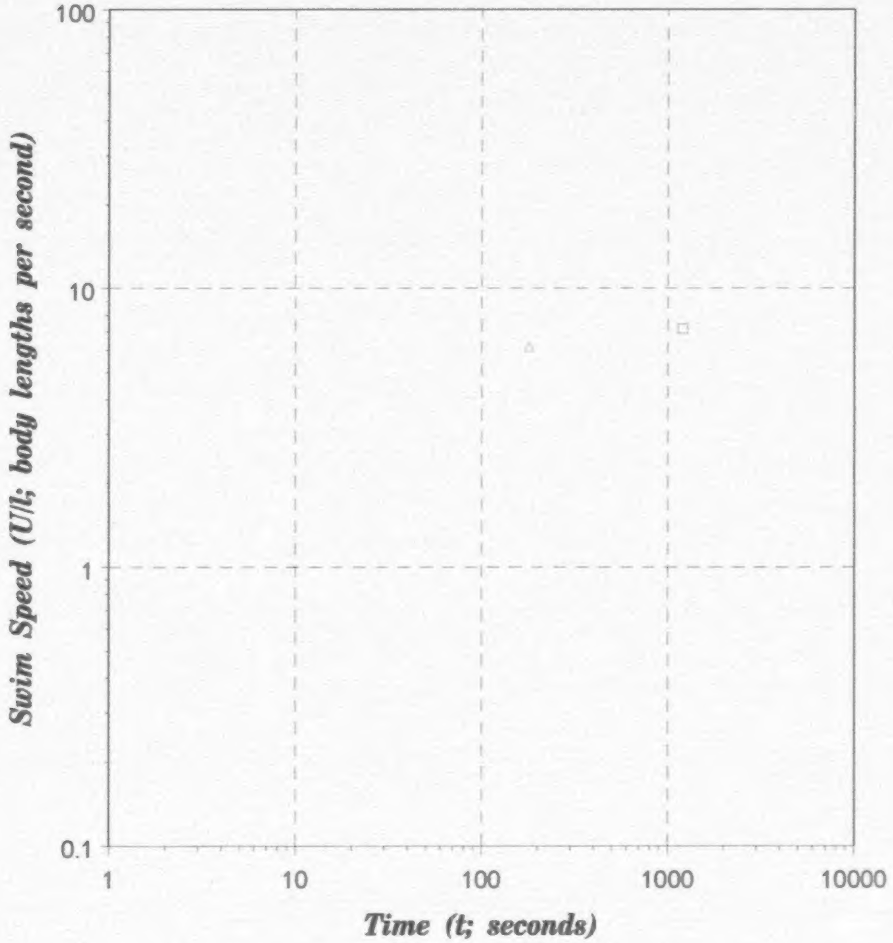


Figure B-095. Processed data for Pimephales promelas *(Fathead Minnow): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Kolok (1998); red triangles are data from Goertzen (2011).*

Table B-095. Data summary. Fish count 75, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.047	0.019	0.021	0.061	0.04	2
T (C)	22.6	1.9	20	24	4	2
U (m/s)	0.329	0.146	0.13	0.435	0.305	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	846	489	180	1200	1020	2

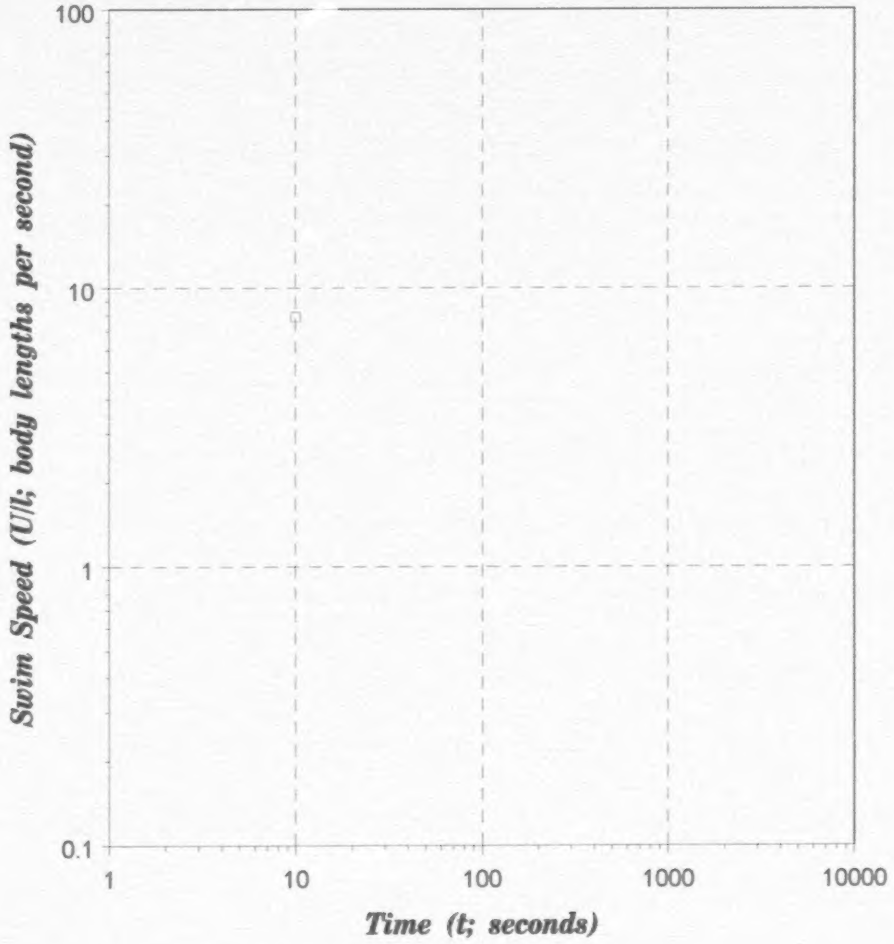


Figure B-096. Processed data for Pimephales vigilax *(Bullhead Minnow):time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Leavy and Bonner (2009).*

Table B-096. Data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.005	0	0.05	0.05	0	1
T (C)	23.4	0	23.4	23.4	0	1
U (m/s)	0.396	0	0.396	0.396	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

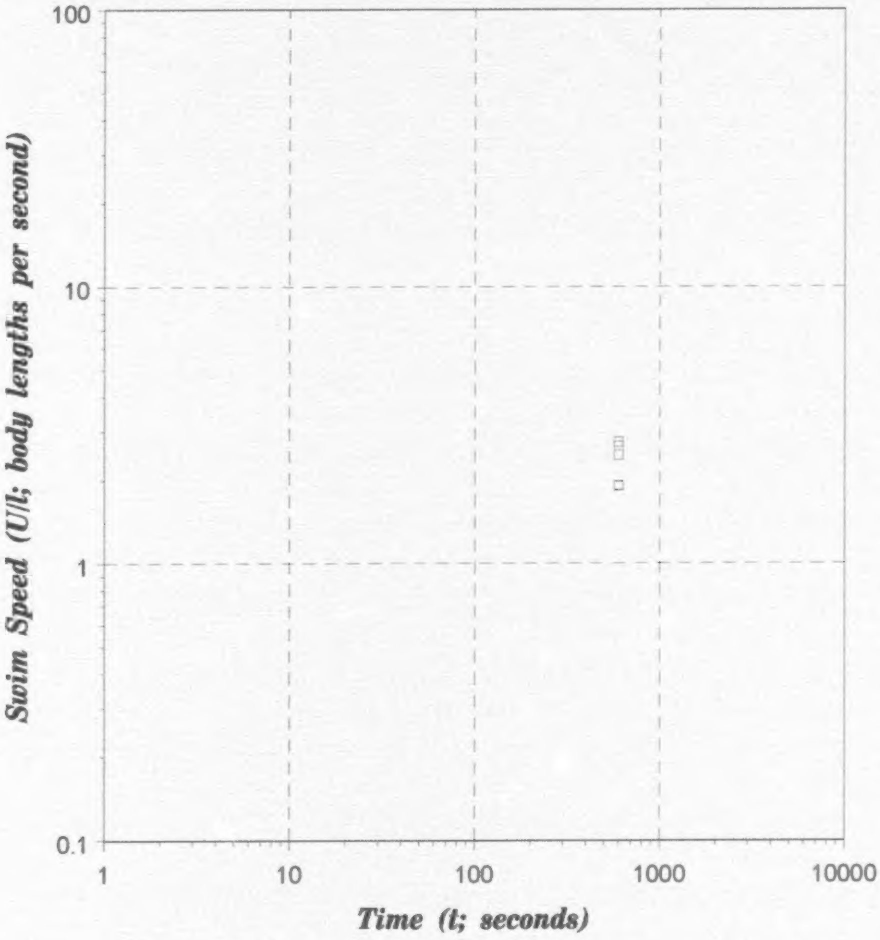


Figure B-097. Processed data for Platygobio gracilus *(Flathead Chub): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973).*

Table B-097. Data summary. Fish count 26, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.233	0.039	0.175	0.288	0.113	5
T (C)	16	0	16	16	0	1
U (m/s)	0.556	0.091	0.367	0.625	0.258	5
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

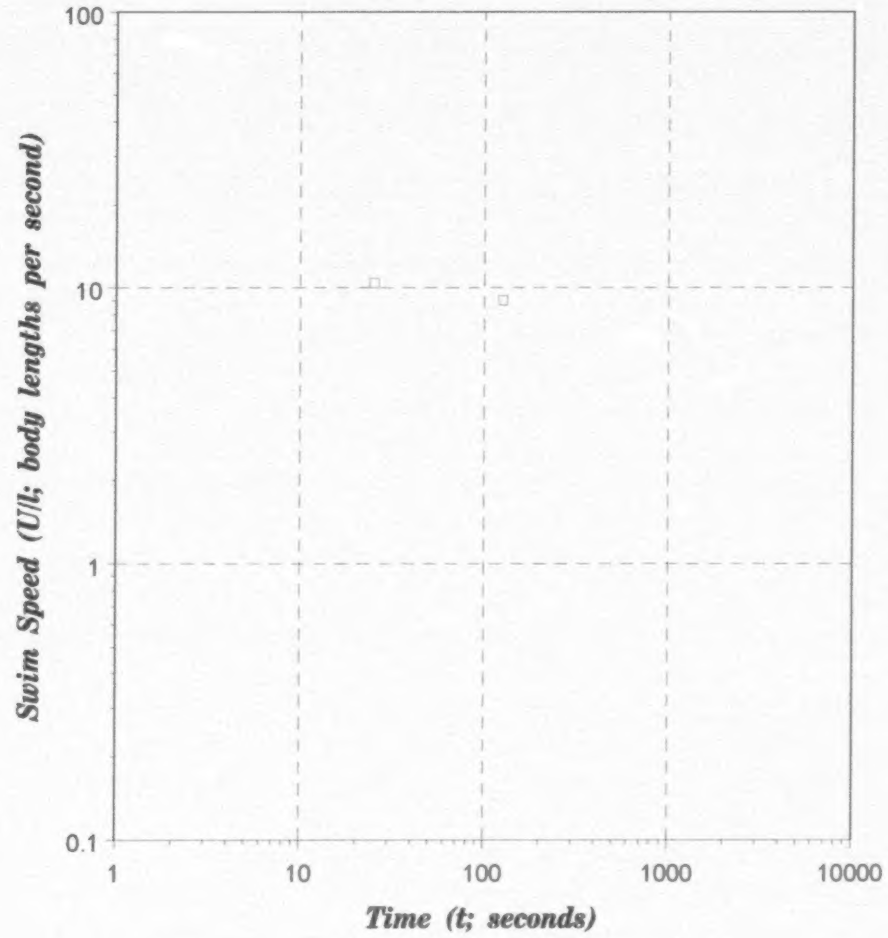


Figure B-098. Processed data for Plecoglossus altivelis *(Ayu): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Tsukamoto (1975).*

Table B-098. Data summary. Fish count 20, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.144	0	0.144	0.144	0	1
T (C)	18	0	18	18	0	1
U (m/s)	1.4	0.103	1.3	1.55	0.2	2
t_e (s)	76	52	25	126	101	2
$t_{\Delta t}$ (s)	.	.	.	.	.	0

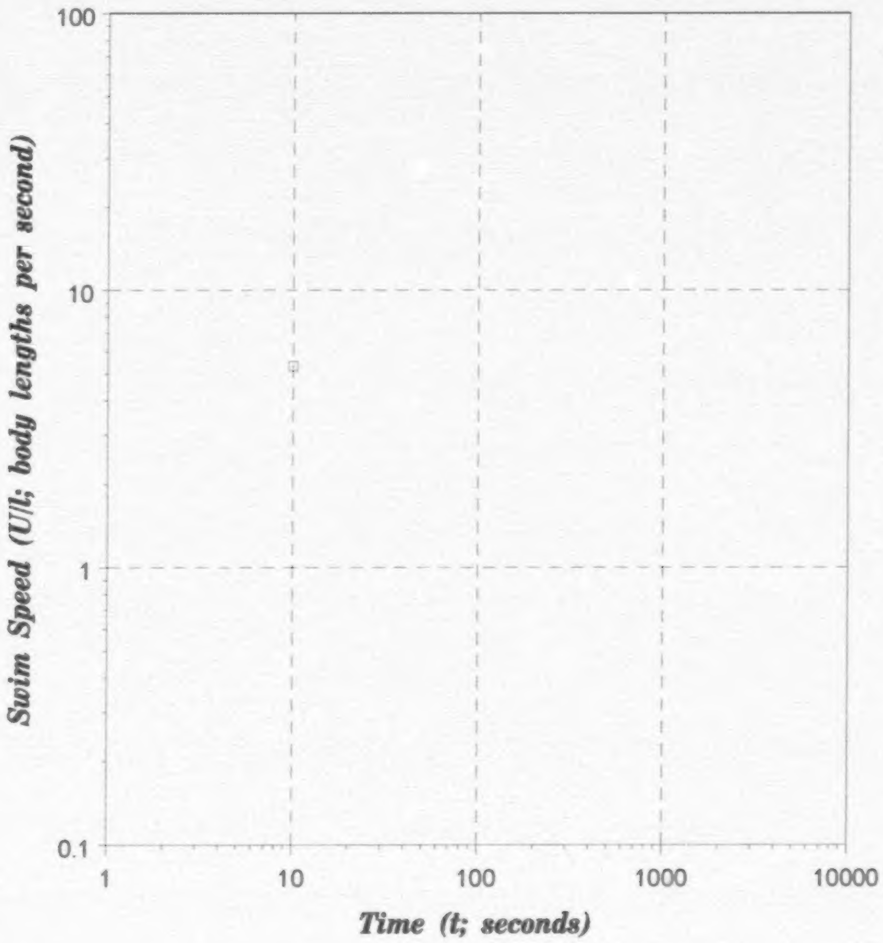


Figure B-099. Processed data for Poecilia latipinna *(Sailfin Molly): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-099. Data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	22.7	0	22.7	22.7	0	1
U (m/s)	0.186	0	0.186	0.186	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

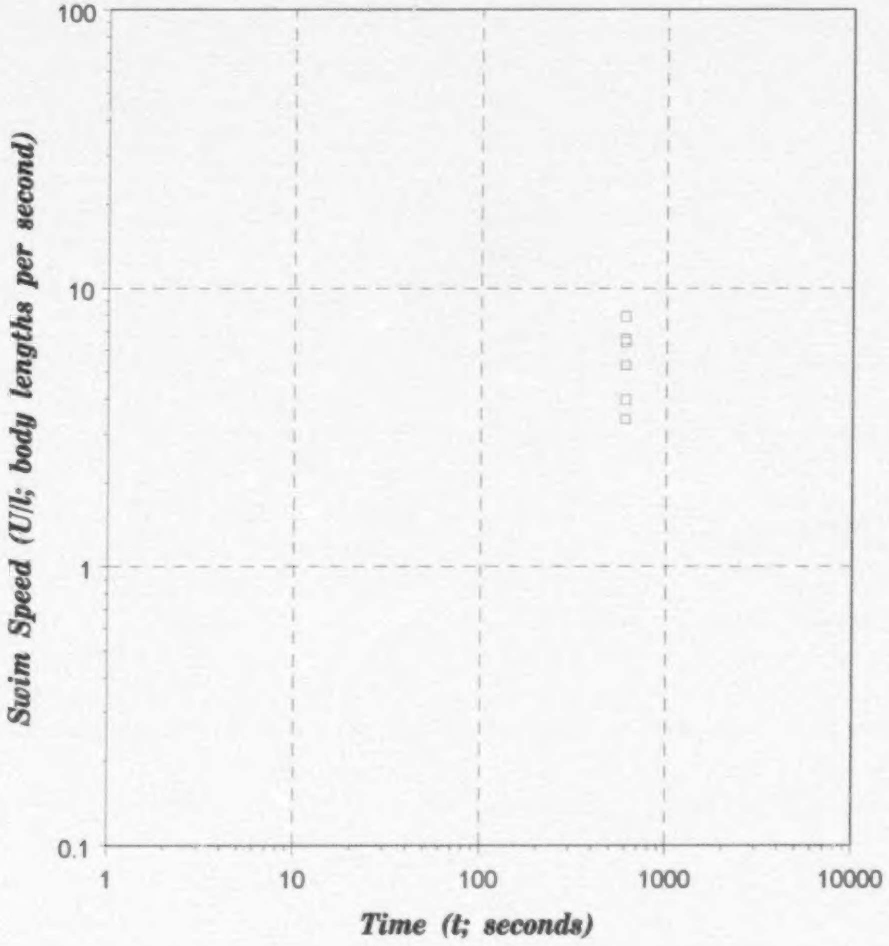


Figure B-100. Processed data for Pogonichthys macrolepidotus *(Sacramento Splittail): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Cech and Young (1995).*

Table B-100. Data summary. Fish count 66, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.079	0.058	0.029	0.195	0.166	6
T (C)	18	1.4	17	20	3	2
U (m/s)	0.365	0.152	0.19	0.66	0.47	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

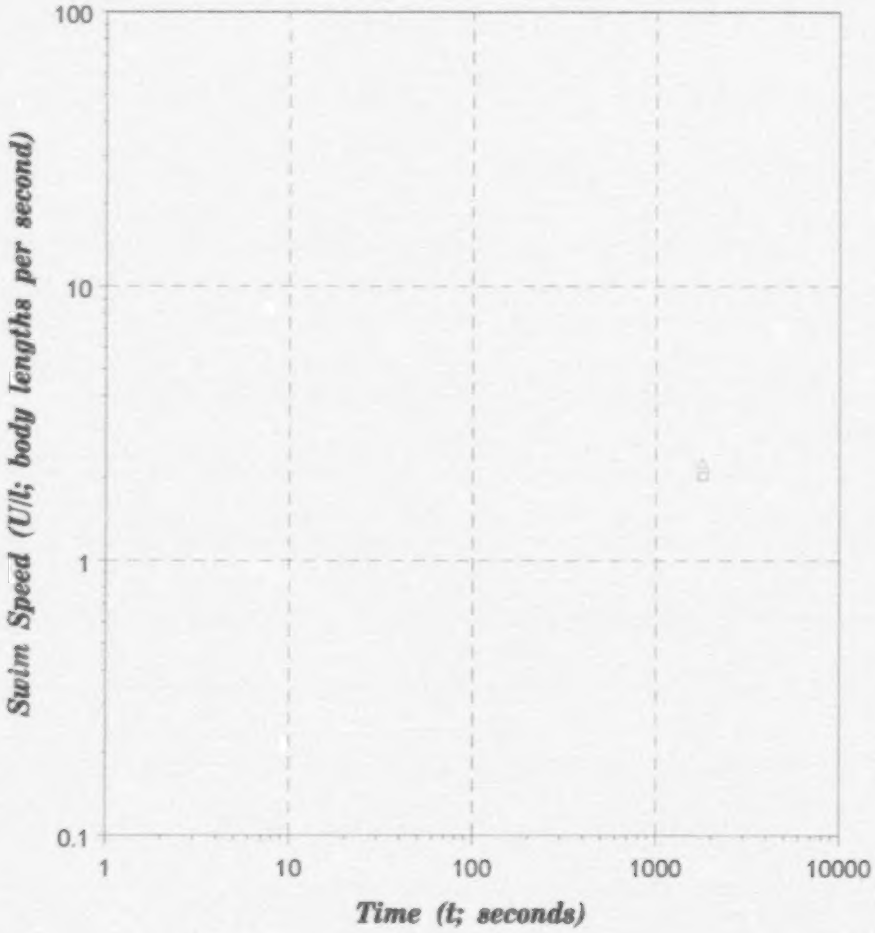


Figure B-101. Processed data for Pomoxis annularis *(White Crappie): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Parsons and Sylvester (1992); red triangle is data from Parsons (1993).*

Table B-101. Data summary. Fish count 19, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.17	0	0.17	0.17	0	1
T (C)	25	0	25	25	0	1
U (m/s)	0.362	0.02	0.347	0.387	0.04	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

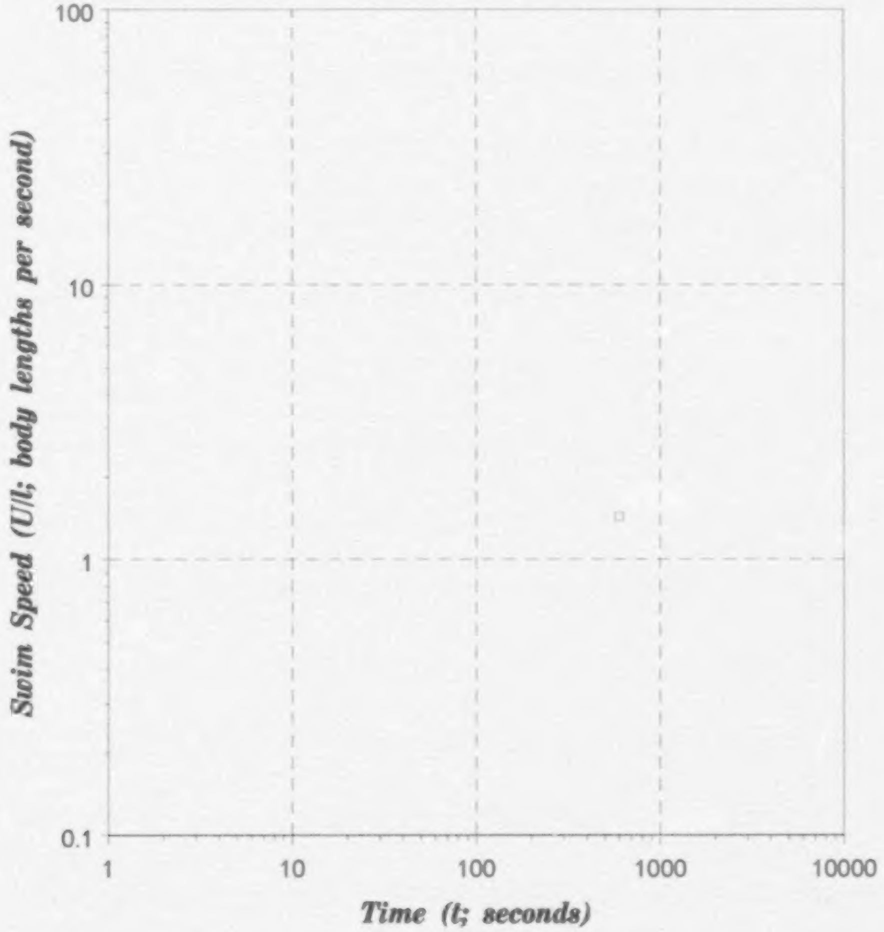


Figure B-102. Processed data for Prosopium williamsoni *(Mountain Whitefish): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Jones et al. (1973).*

Table B-102. Data summary. Fish count 9, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0	0.3	0.3	0	1
T (C)	10	0	10	10	0	1
U (m/s)	0.43	0	0.43	0.43	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

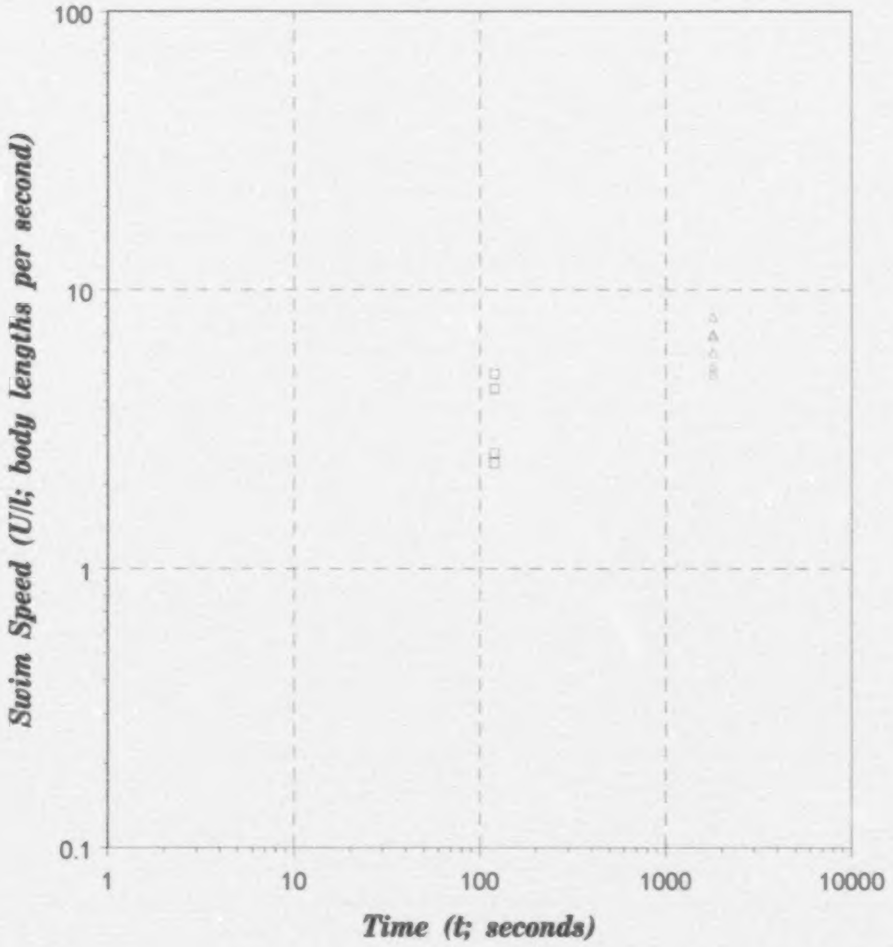


Figure B-103. Processed data for Ptychocheilus lucius *(Colorado Squawfish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Berry and Pimentel (1985); red triangles are data from Childs and Clarkson (1996).*

Table B-103. Data summary. Fish count 345, record count 11.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.111	0.133	0.022	0.451	0.43	11
T (C)	17.4	5.6	10	26	16	4
U (m/s)	0.406	0.301	0.133	1.08	0.947	11
t_e (s)	870	836	120	1800	1680	2
$t_{\Delta t}$ (s)	.	.	.	.	.	0

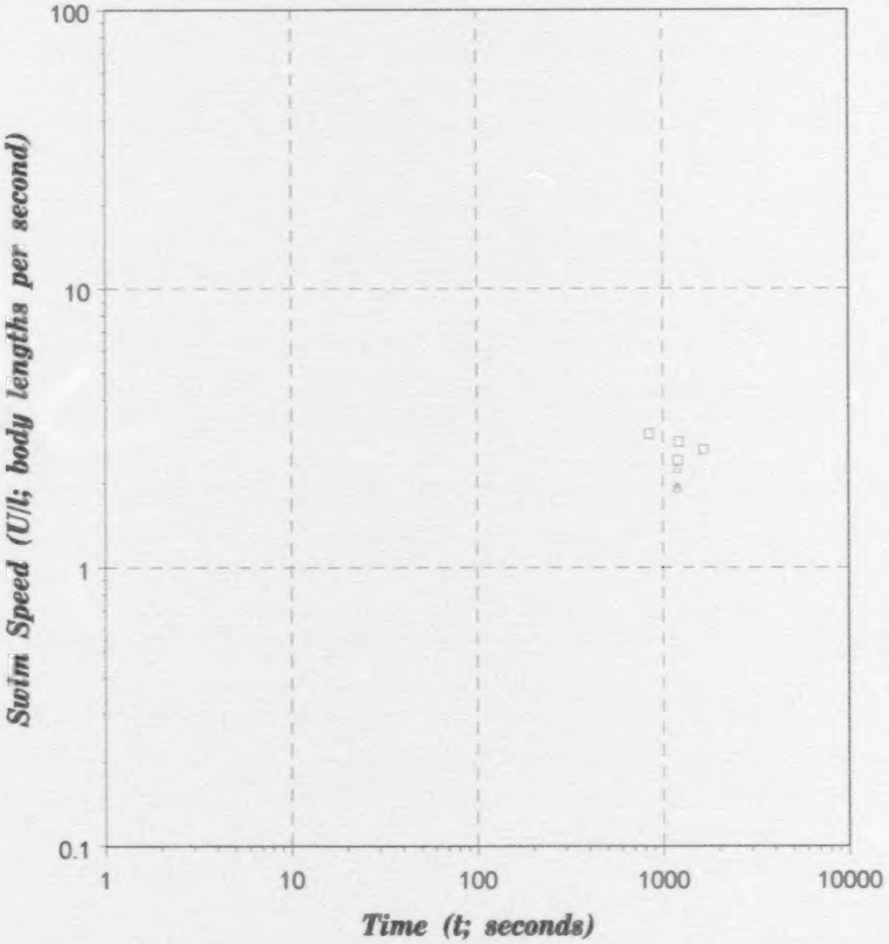


Figure B-104. Processed data for Ptychocheilus oregonensis *(Northern Squawfish): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Mesa and Olson (1993); red triangles are data from Kolok and Farrell (1994a); green stars are data from Kolok and Farrell (1994b).*

Table B-104. Data summary. Fish count 106, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.35	0.061	0.25	0.435	0.185	5
T (C)	14.5	3.8	5	18	13	4
U (m/s)	0.856	0.252	0.484	1.15	0.666	7
t_e (s)	1242	299	846	1662	816	4
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

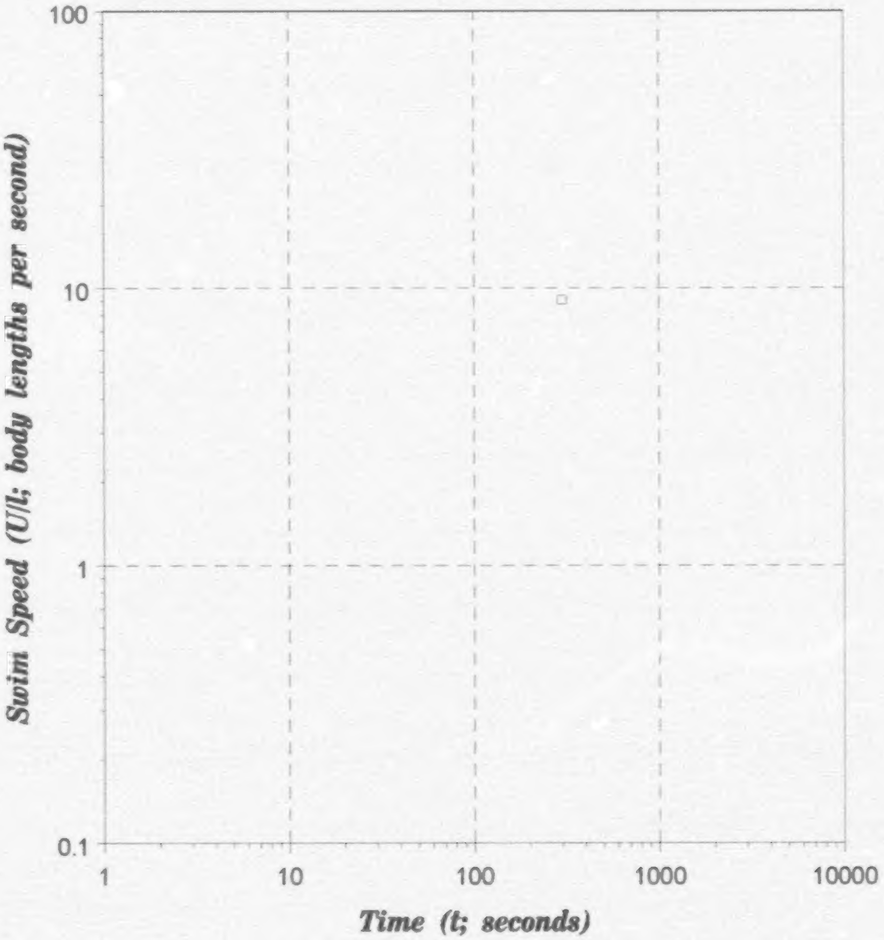


Figure B-105. Processed data for Rhinichthys atratulus *(Blacknose Dace): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Nelson et al. (2003).*

Table B-105. Data summary. Fish count 32, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0.001	0.043	0.043	0	1
T (C)	24	0	24	24	0	1
U (m/s)	0.387	0.087	0.387	0.387	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

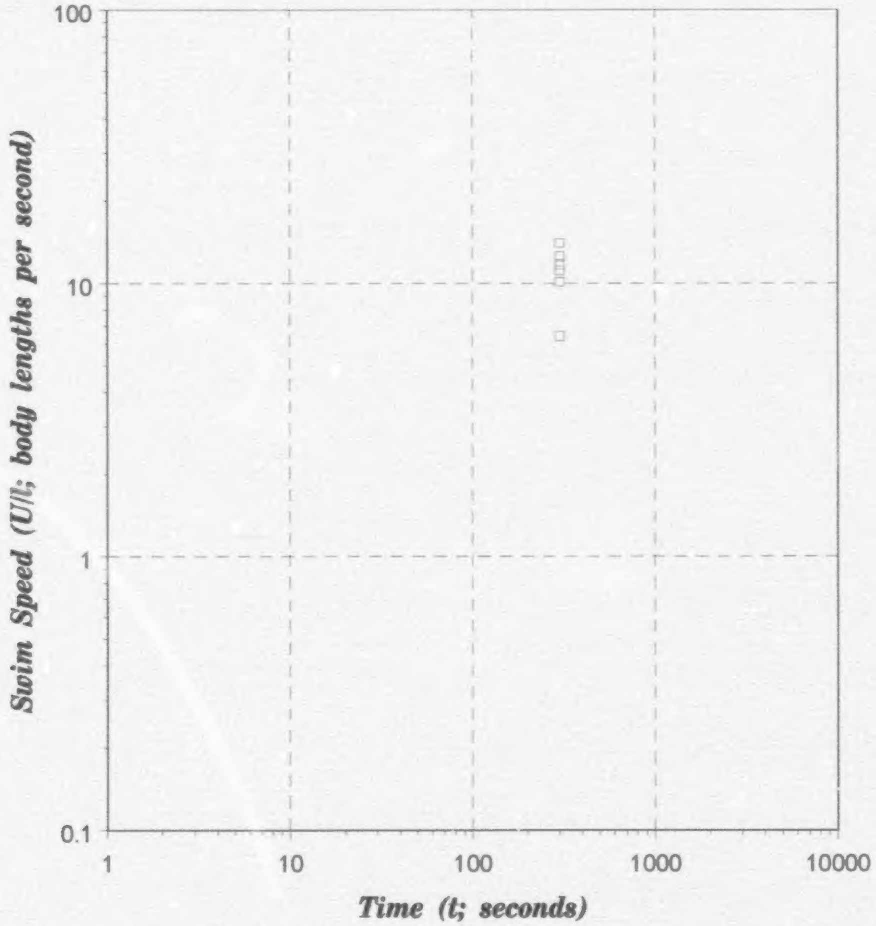


Figure B-106. Processed data for Rhinichthys cataractae *(Longnose Dace): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Aedo et al. (2009).*

Table B-106. Data summary. Fish count 15, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.066	0.016	0.04	0.087	0.046	6
T (C)	17	0	17	17	0	1
U (m/s)	0.727	0.205	0.415	0.982	0.567	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

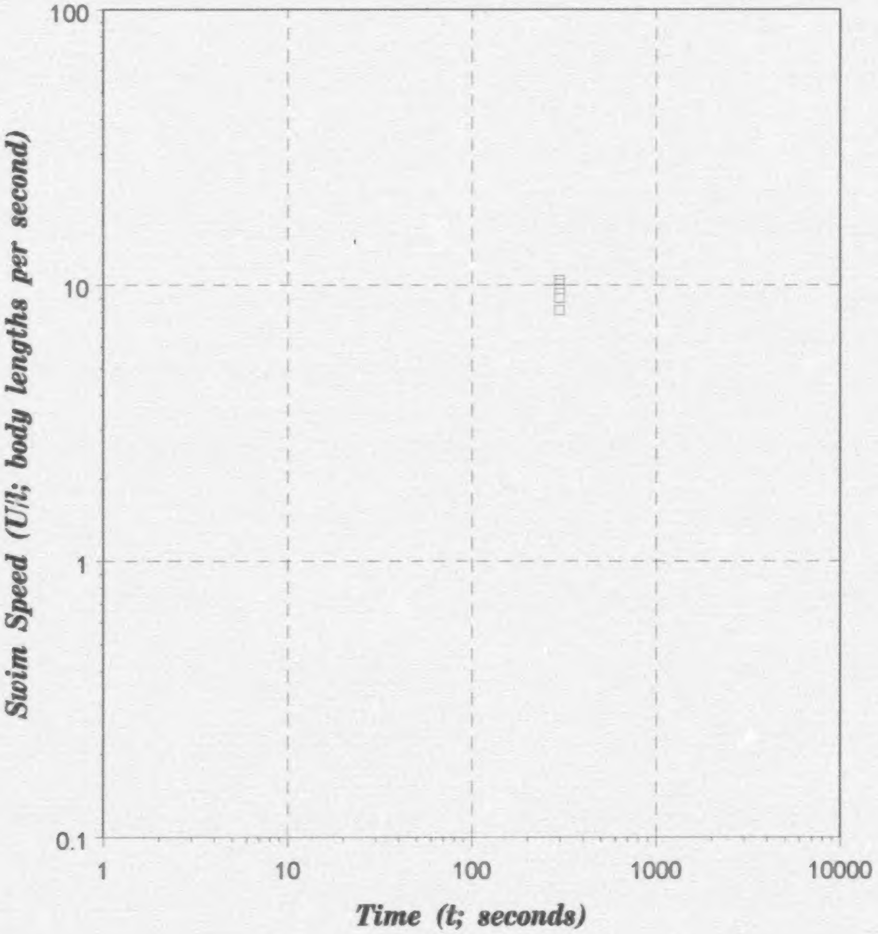


Figure B-107. Processed data for Rhinichthys osculus *(Speckled Dace): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Aedo et al. (2009).*

Table B-107. Data summary. Fish count 20, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.071	0.011	0.048	0.085	0.037	5
T (C)	17	0	17	17	0	1
U (m/s)	0.694	0.127	0.485	0.806	0.321	5
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

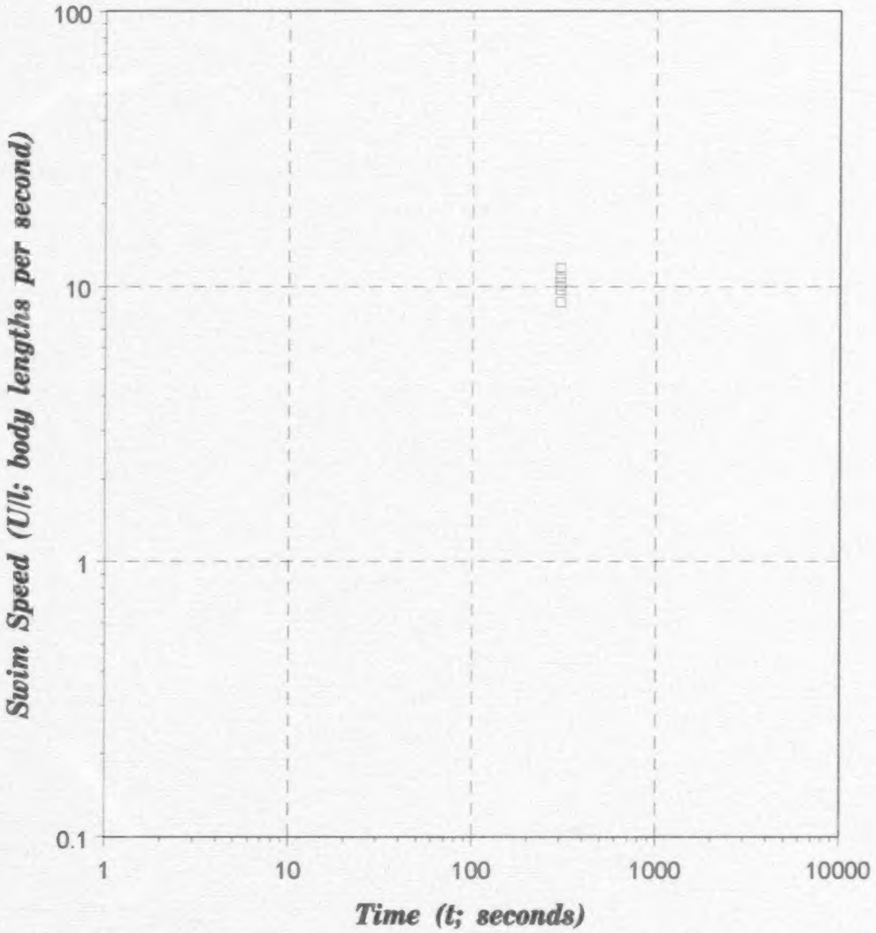


Figure B-108. Processed data for Richardsonius balteatus *(Redside Shiner): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Aedo et al. (2009).*

Table B-108. Data summary. Fish count 18, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.074	0.022	0.035	0.108	0.073	6
T (C)	17	0	17	17	0	1
U (m/s)	0.755	0.192	0.339	0.947	0.608	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

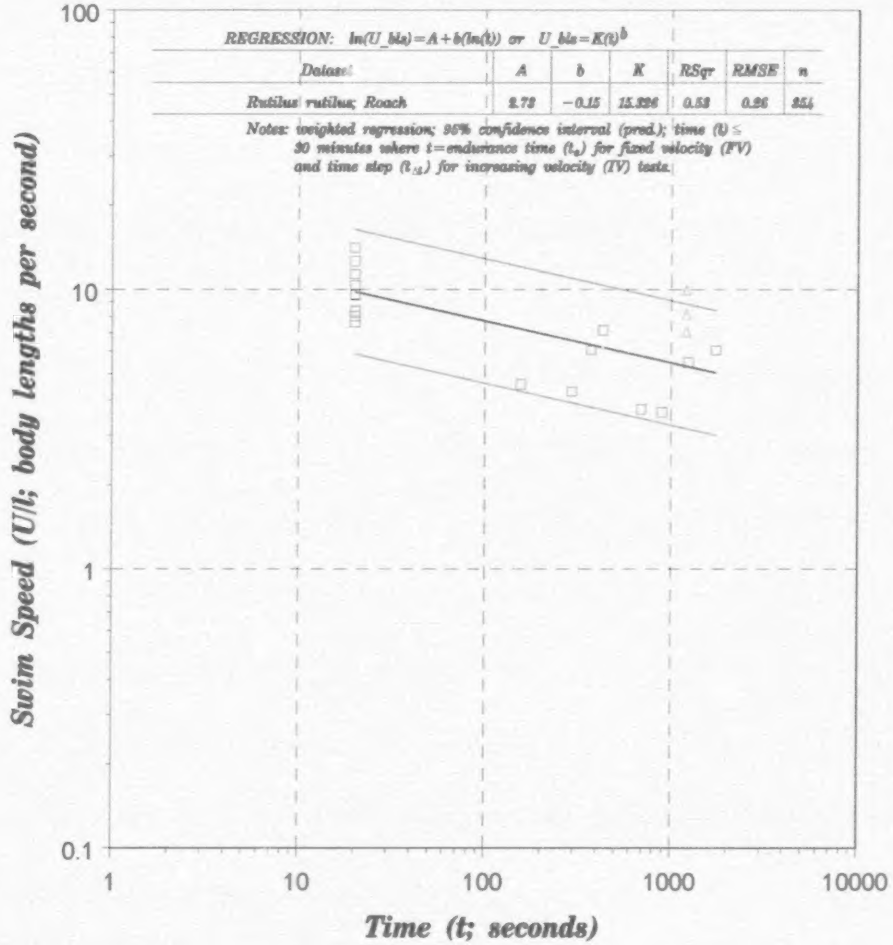
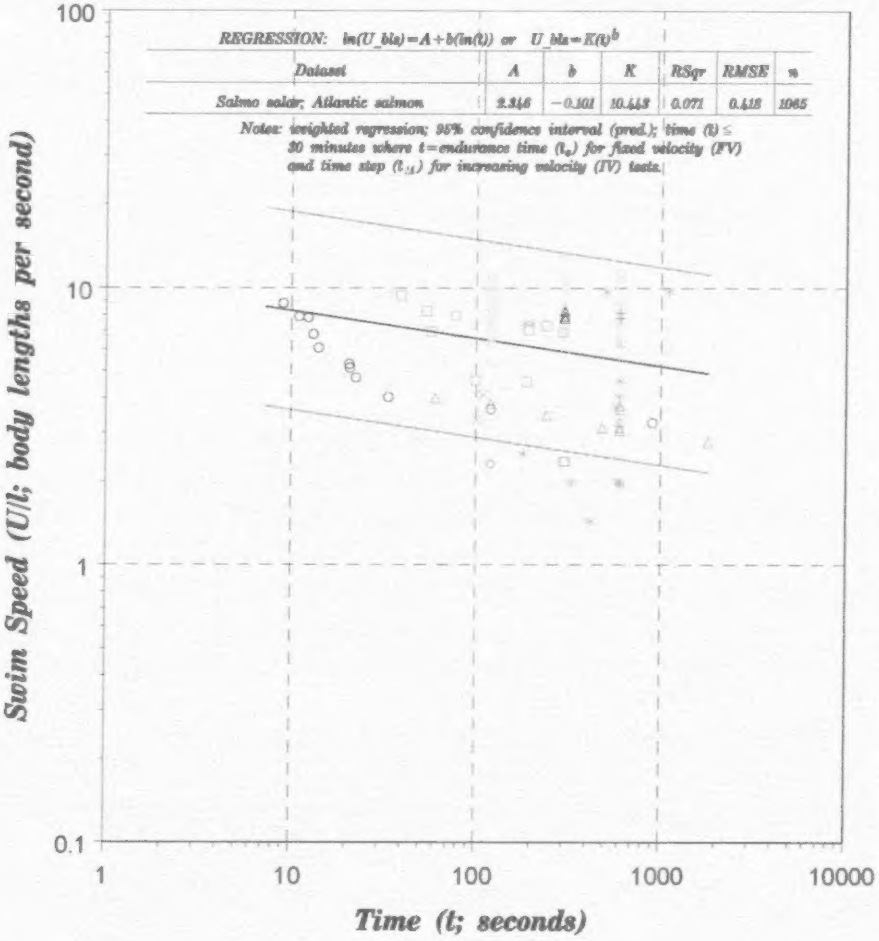


Figure B-109. Processed data for Rutilus rutilus *(Roach): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Clough and Tumpenny (2000); red triangles are data from Tudoraache et al. (2008).*

Table B-109. Data summary. Fish count 354, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.13	0.038	0.046	0.186	0.14	17
T (C)	14.2	3.4	8.8	18.5	9.7	16
U (m/s)	1.017	0.3	0.458	1.552	1.094	14
t_e (s)	867	527	156	1733	1577	8
$t_{\Delta t}$ (s)	141	359	20	1200	1180	2



REGRESSION: $\ln(U\_bls)=A+b(\ln(t))$ or $U\_bls=K(t)^b$

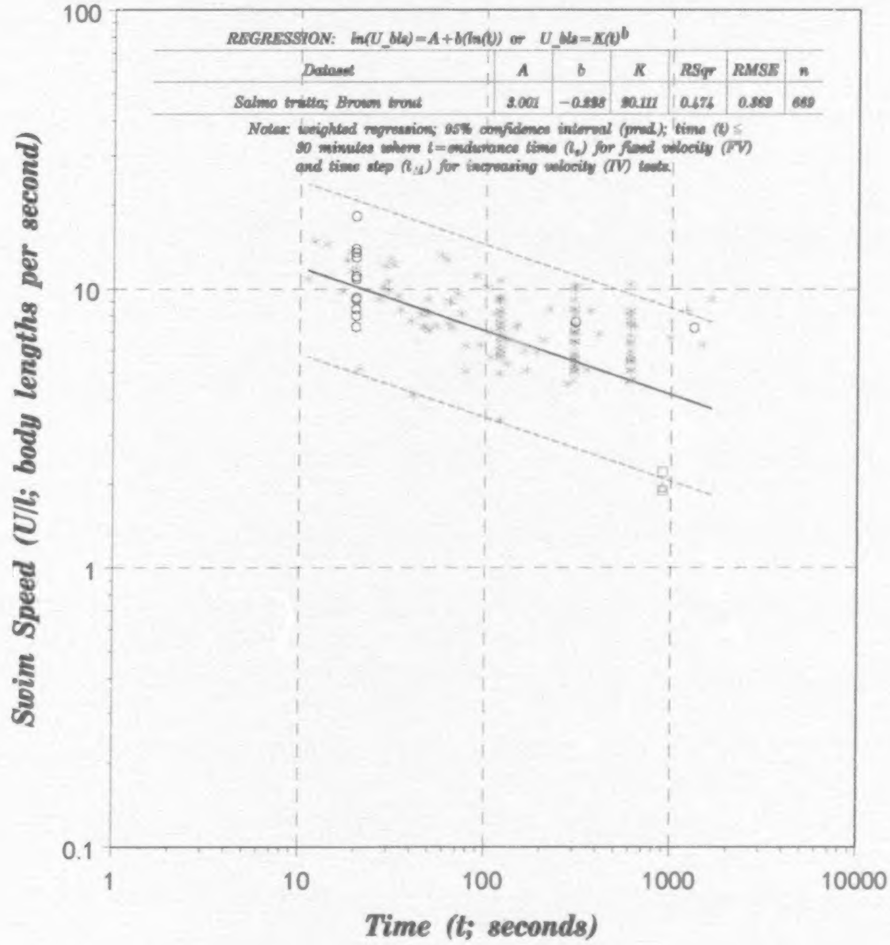
Dataset	A	b	K	RSqr	RMSE	n
Salmo salar; Atlantic salmon	2.346	−0.101	10.443	0.071	0.418	1065

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t=endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure B-110. Processed data for Salmo salar *(Atlantic Salmon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from McCleave and Stred (1975); red triangles are data from Booth et al. (1997a); green stars are data from Booth et al. (1997b); black circles are data from Colavecchia (1997); turquoise diamonds are data from Peake et al. (1997b); blue crossese are data from Peake et al. (1997c); red x's are data from Thorstad et al. (1997); green squares are data from McDonald et al.(1998), black triangles are data from McDonald et al.(1998); turquoise stars are data from Beddow and Mckinley (1999); blue circles are data from Thorstad et al. (2000); red diamonds are data from Enders et al. (2008).*

Table B-110. Data summary. Fish count 1065, record count 145.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.213	0.173	0.048	0.615	0.567	104
T (C)	13.1	3.5	4	20.5	16.5	55
U (m/s)	1.199	0.842	0.38	4.49	4.11	128
t_e (s)	164	224	7	1800	1793	44
$t_{\Delta t}$ (s)	430	187	120	600	480	3



REGRESSION: $\ln(U\_bls) = A + b(\ln(t))$ or $U\_bls = K(t)^b$

Dataset	A	b	K	RSqr	RMSE	n
Salmo trutta; Brown trout	3.001	−0.238	20.111	0.474	0.363	669

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure B-111. Processed data for Salmo trutta *(Brown Trout): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Butler et al. (1992); red triangles are data from Beaumont et al. (1995a); green stars are data from Peake et al. (1997b); black circles are data from Clough and Tumpenny (2000); turquoise diamonds are data from Ojanguran and Brana (2003); blue crosses are data from Tudorache et al. (2008); red x's are data from Aedo et al. (2009).*

Table B-111. Data summary. Fish count 669, record count 160.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.153	0.076	0.048	0.4	0.353	132
T (C)	11.4	4.8	5	21.2	16.2	17
U (m/s)	1.085	0.431	0.316	1.788	1.472	95
t_e (s)	315	441	11	1652	1641	69
$t_{\Delta t}$ (s)	245	326	20	1200	1180	6

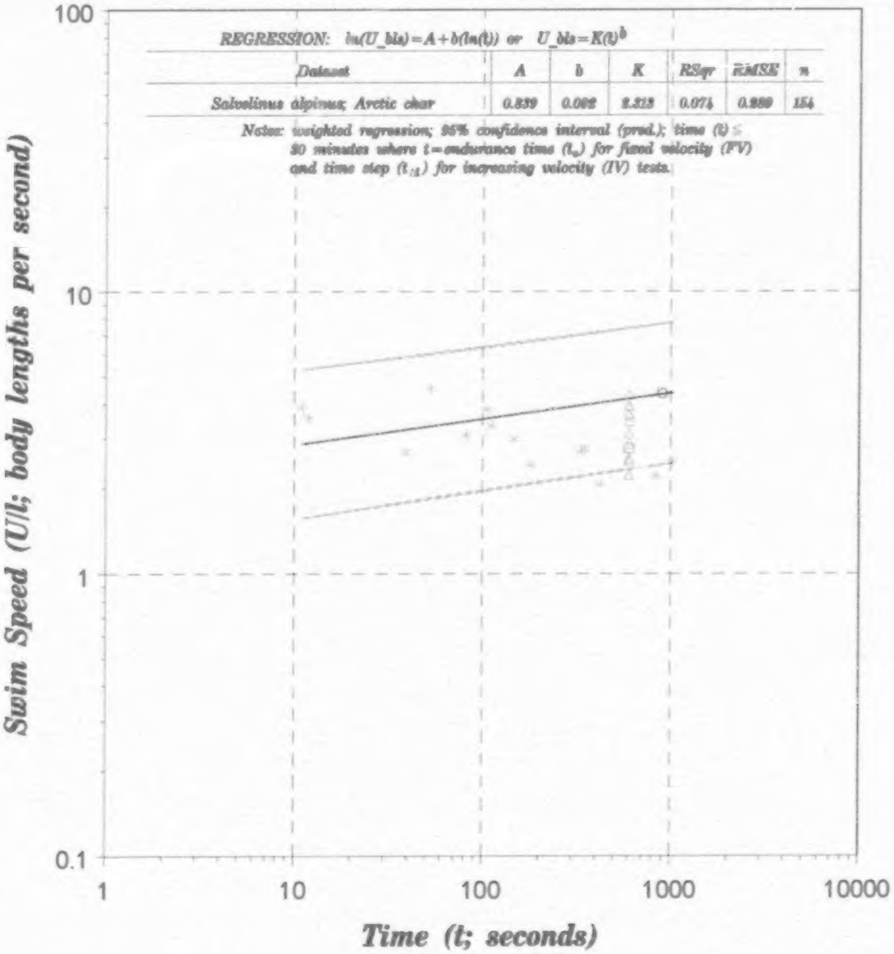


Figure B-112. Processed data for Salvelinus alpinus *(Arctic Char): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Jones et al. (1973); red triangles are data from Welch (1979); green stars are data from Beamish (1980); black circles are data from Hunter and Scherer (1988); turquoise diamonds are data from Jones and Moffitt (2004).*

Table B-112. Data summary. Fish count 154, record count 30.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.227	0.084	0.077	0.401	0.324	28
T (C)	11.1	2.4	9	15	6	4
U (m/s)	0.901	0.187	0.33	1.3	0.97	17
t_e (s)	616	286	11	1028	1017	17
$t_{\Delta t}$ (s)	664	124	600	900	300	2

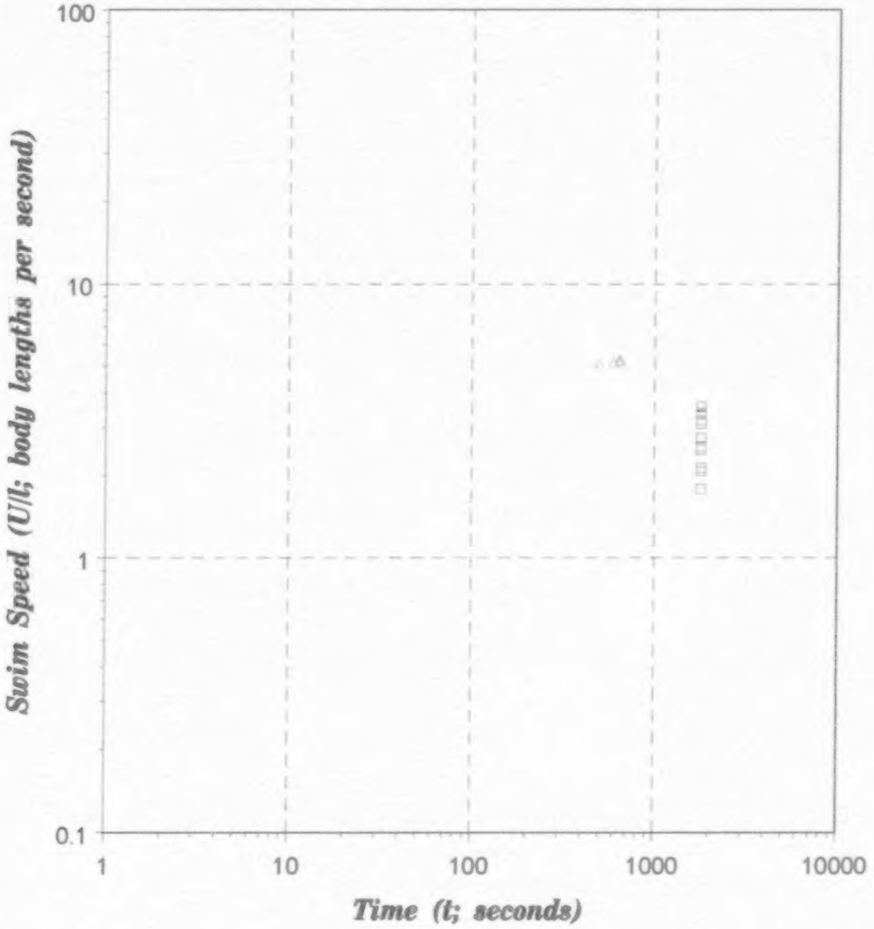


Figure B-113. Processed data for Salvelinus confluentus *(Bull Trout): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Mesa et al. (2003b); red triangles are data from Jones and Moffitt (2004).*

Table B-113. Data summary. Fish count 106, record count 16.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.207	0.046	0.109	0.425	0.316	15
T (C)	12.3	2.9	9	15	6	3
U (m/s)	0.977	0.193	0.272	1.15	0.878	15
t_e (s)	598	60	494	647	153	4
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

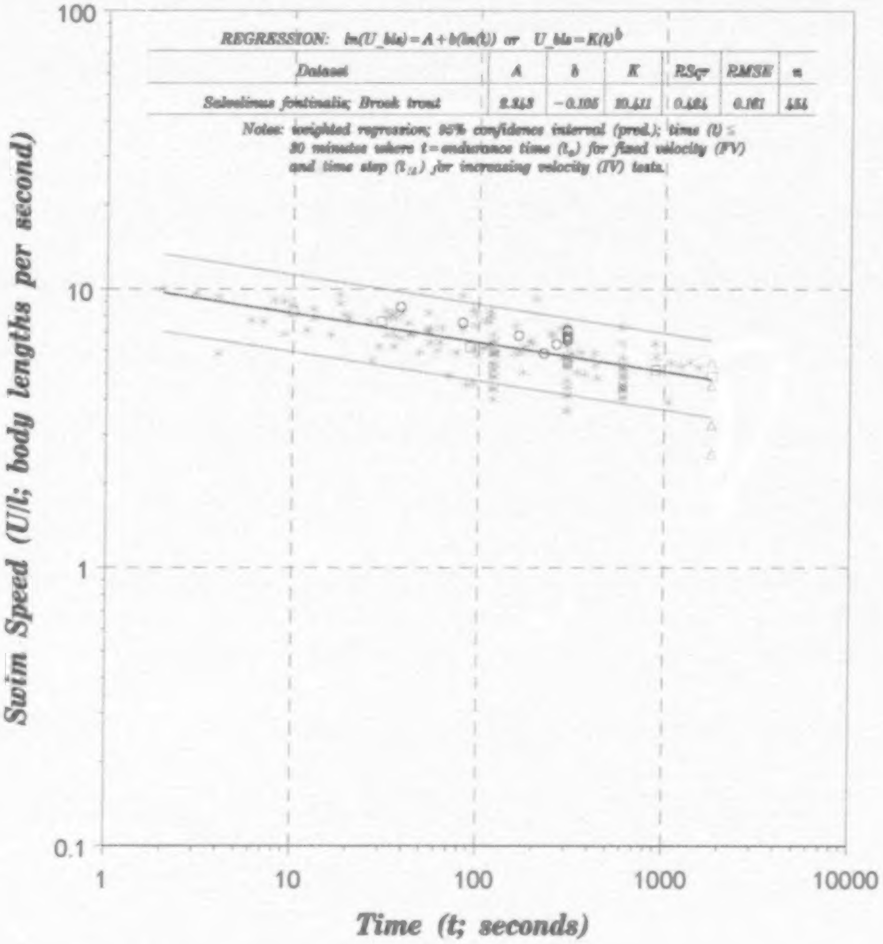


Figure B-114. Processed data for Salvelinus fontinalis *(Brook Trout): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Peterson (1974); red triangles are data from Beamish (1980); green stars are data from Peake et al. (1997b); black circles are data from McDonald et al. (1998); turquoise diamonds are from Paul et al. (2005).*

Table B-114. Data summary. Fish count 454, record count 177.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.129	0.063	0.039	0.405	0.367	147
T (C)	15.9	2.9	9.5	20	10.5	36
U (m/s)	0.755	0.348	0.21	1.843	1.633	117
t_e (s)	261	324	2	1537	1535	79
$t_{\Delta t}$ (s)	612	605	10	1800	1790	8

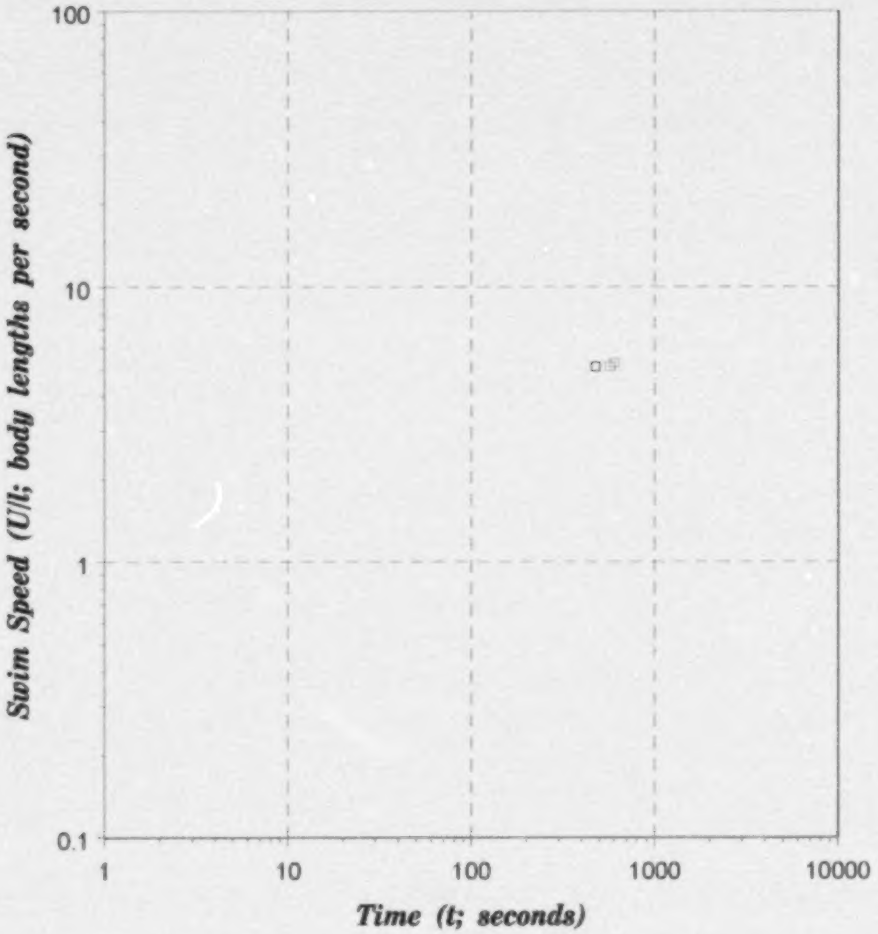


Figure B-115. Processed data for for Salvelinus namaycush *(Lake Trout): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones and Moffitt (2004).*

Table B-115. Data summary. Fish count 90, record count 4.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.202	0.021	0.175	0.225	0.05	4
T (C)	12.3	3	9	15	6	2
U (m/s)	1.044	0.102	0.9	1.15	0.25	3
t_e (s)	538	58	473	603	130	4
$t_{\Delta t}$ (s)	.	.	.	.	.	0

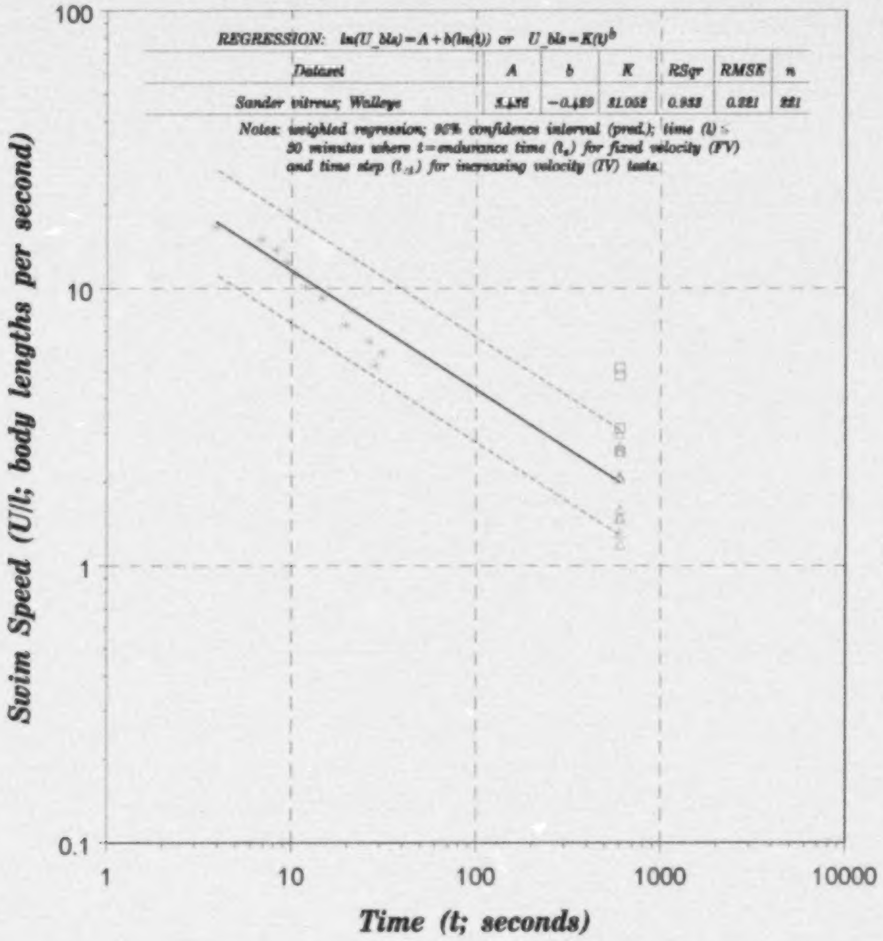


Figure B-116. Processed data for Sander vitreus *(Walleye): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973); red triangles are data from Peake et al. (2000); green stars are data from Castro-Santos (2005).*

Table B-116. Data summary. Fish count 221, record count 28.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.339	0.1	0.07	0.665	0.595	17
T (C)	13.8	1.7	12.7	20	7.3	3
U (m/s)	2.601	1.558	0.34	5.292	4.952	28
t_e (s)	13	7	4	74	72	96
$t_{\Delta t}$ (s)	600	0	600	600	0	1

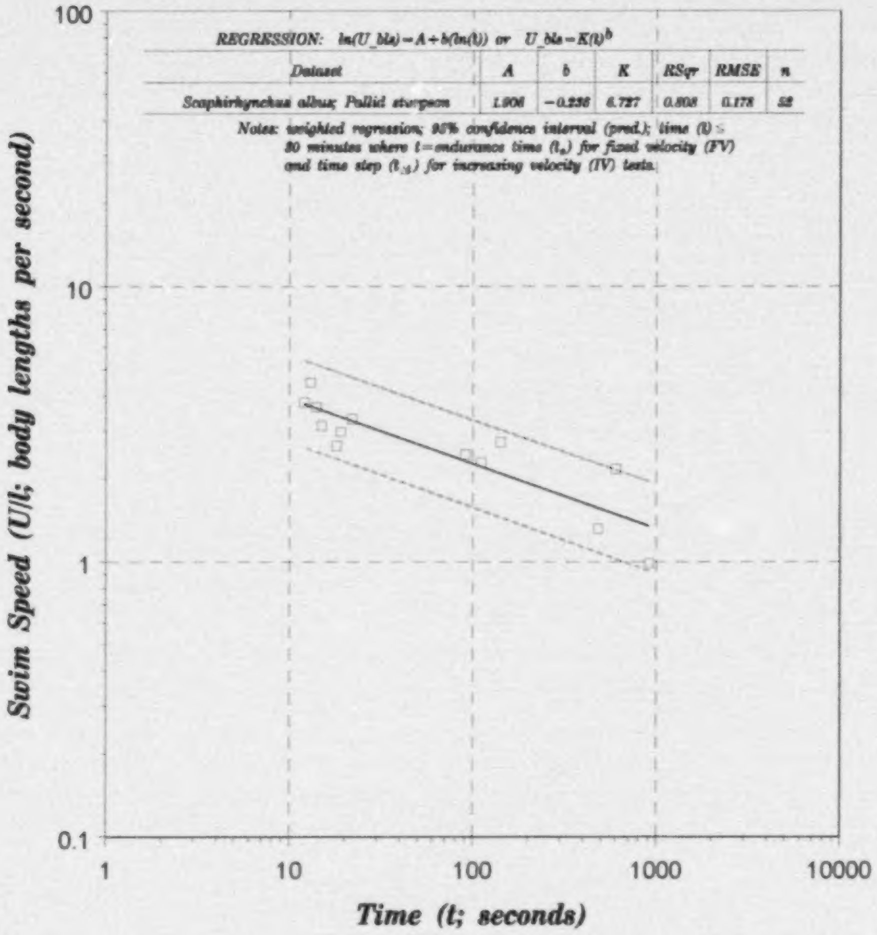


Figure B-117. Processed data for Scaphirhynchus albus *(Pallid Sturgeon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Adams et al. (1999).*

Table B-117. Data summary. Fish count 52, record count 13.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.166	0.152	0.152	0.184	0.032	2
T (C)	18.5	0	18.5	18.5	0	1
U (m/s)	0.492	0.161	0.15	0.68	0.53	9
t_e (s)	154	258	12	912	900	13
$t_{\Delta t}$ (s)	.	.	.	.	.	0

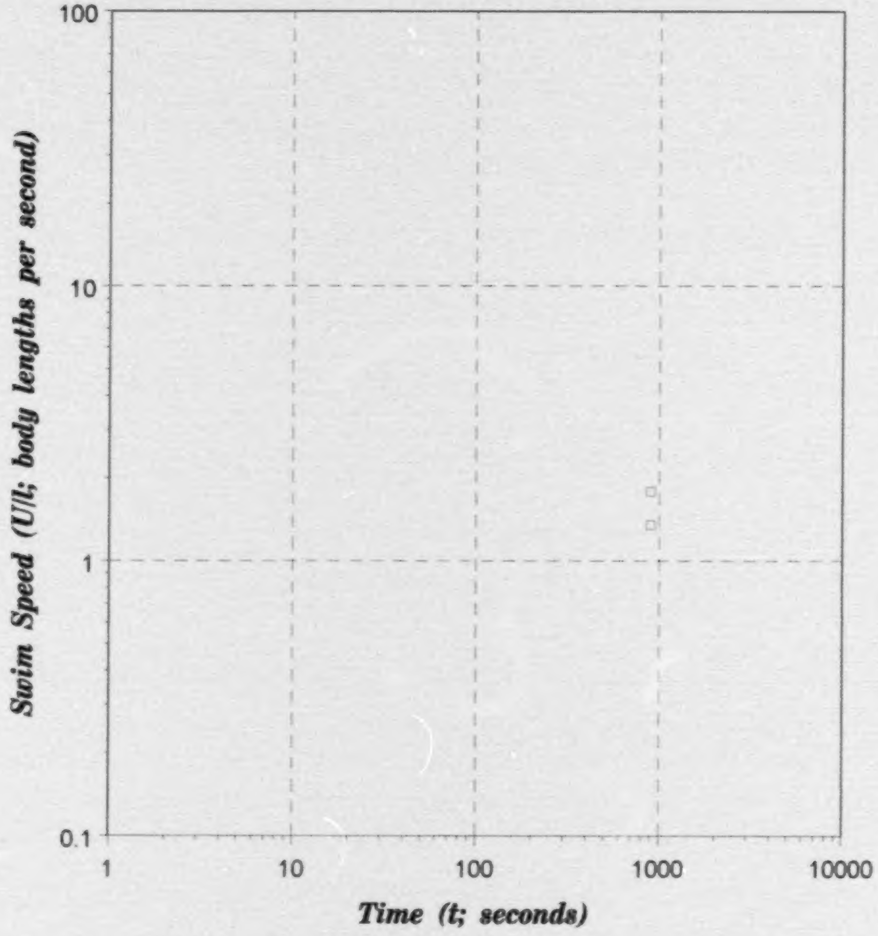


Figure B-118. Processed data for Scaphirhynchus platorynchus *(Shovelnose Sturgeon): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Adams et al. (1997).*

Table B-118. Data summary. Fish count 5, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.631	0.056	0.57	0.672	0.102	2
T (C)	16	0	16	16	0	1
U (m/s)	0.953	0.61	0.909	1.02	0.111	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	900	0	900	900	0	1

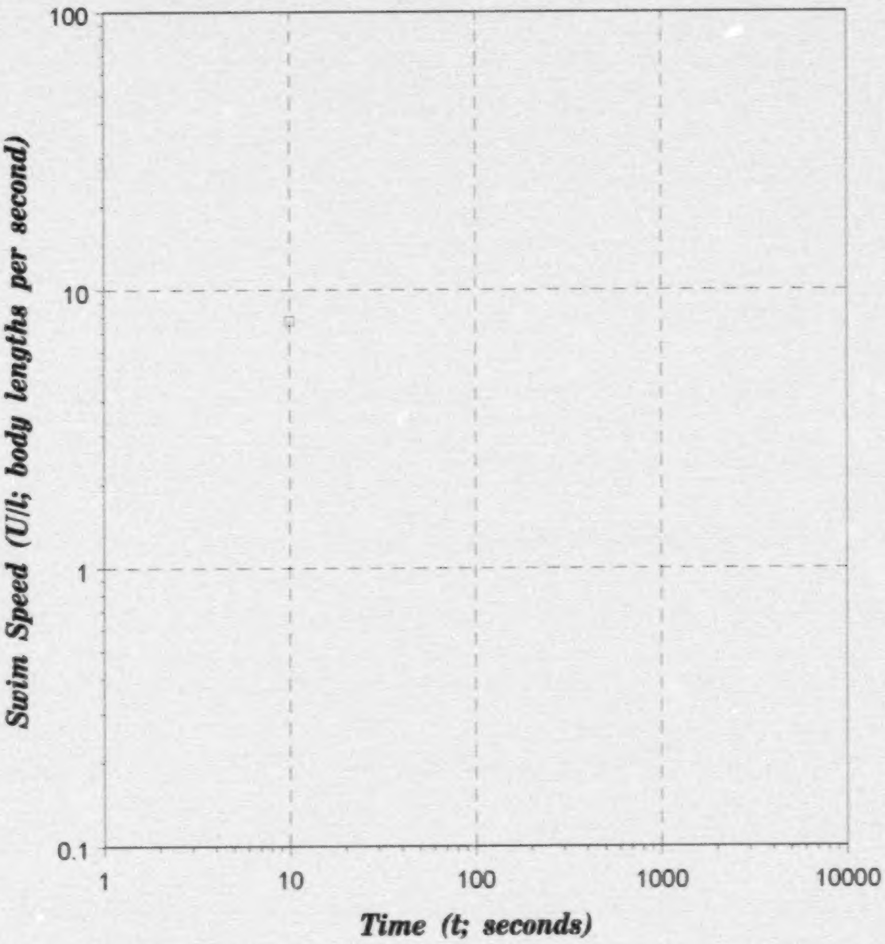


Figure B-119. Processed data for Semotilus atromaculatus *(Creek Chub): time-to-fatigue versus swim speed (body lengths per second). Blue square is data from Leavy and Bonner (2009).*

Table B-119. Data summary. Fish count 9, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.057	0	0.057	0.057	0	1
T (C)	28.5	0	28.5	28.5	0	1
U (m/s)	0.442	0	0.442	0.442	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

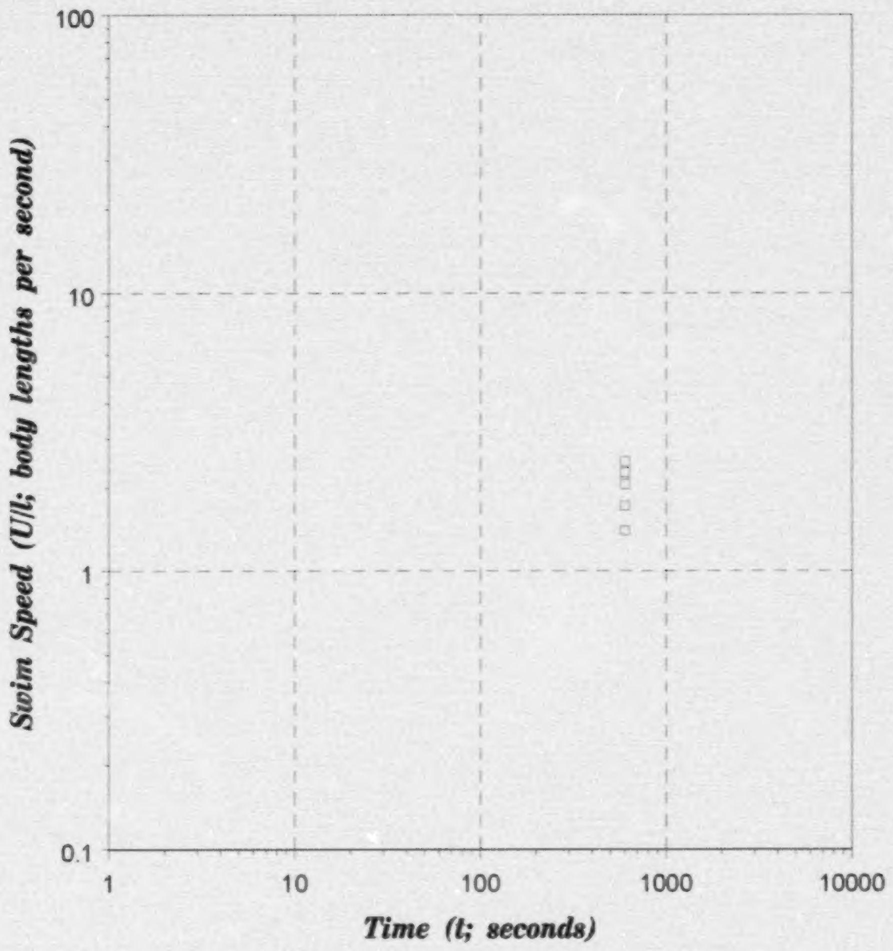


Figure B-120. Processed data for Stenodus leucichthys *(Inconnu): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973).*

Table B-120. Data summary. Fish count 19, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.296	0.089	0.174	0.403	0.229	5
T (C)	16	0	16	16	0	1
U (m/s)	0.603	0.141	0.28	0.703	0.423	5
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

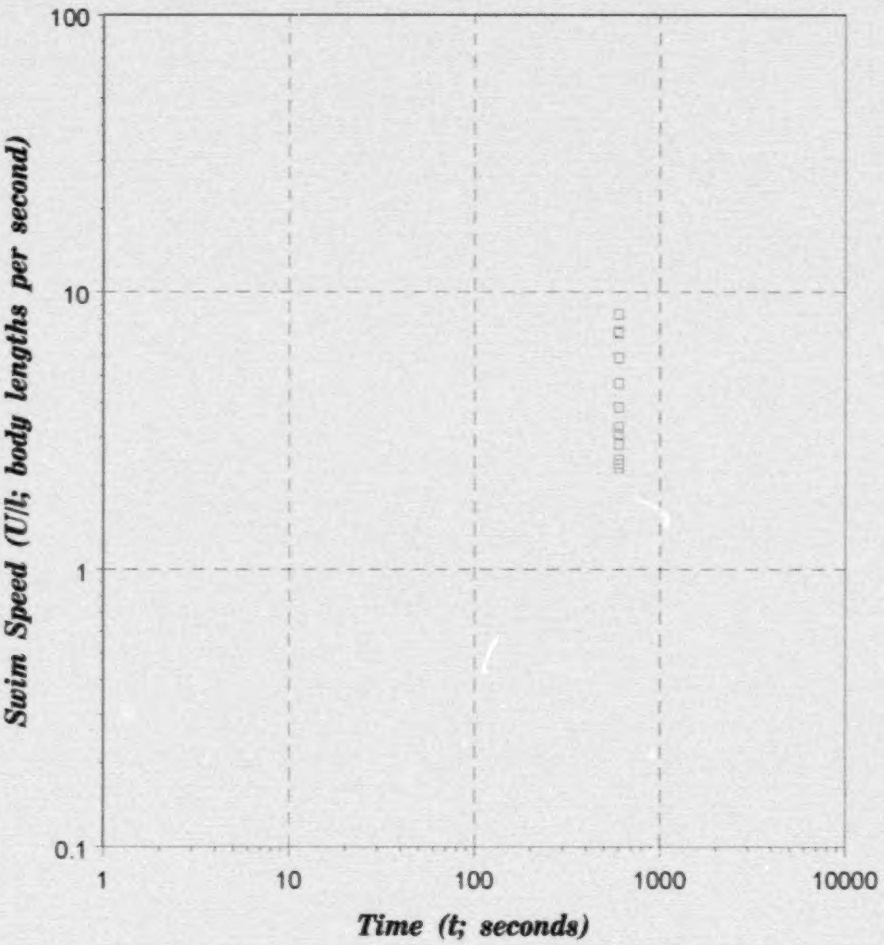


Figure B-121. Processed data for Thymallus arcticus *(Arctic Grayling): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Jones et al. (1973).*

Table B-121. Data summary. Fish count 89, record count 12.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.227	0.071	0.06	0.36	0.3	12
T (C)	16	0	16	16	0	1
U (m/s)	0.673	0.58	0.5	0.835	0.335	12
t_e (s)	-	-	-	-	-	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

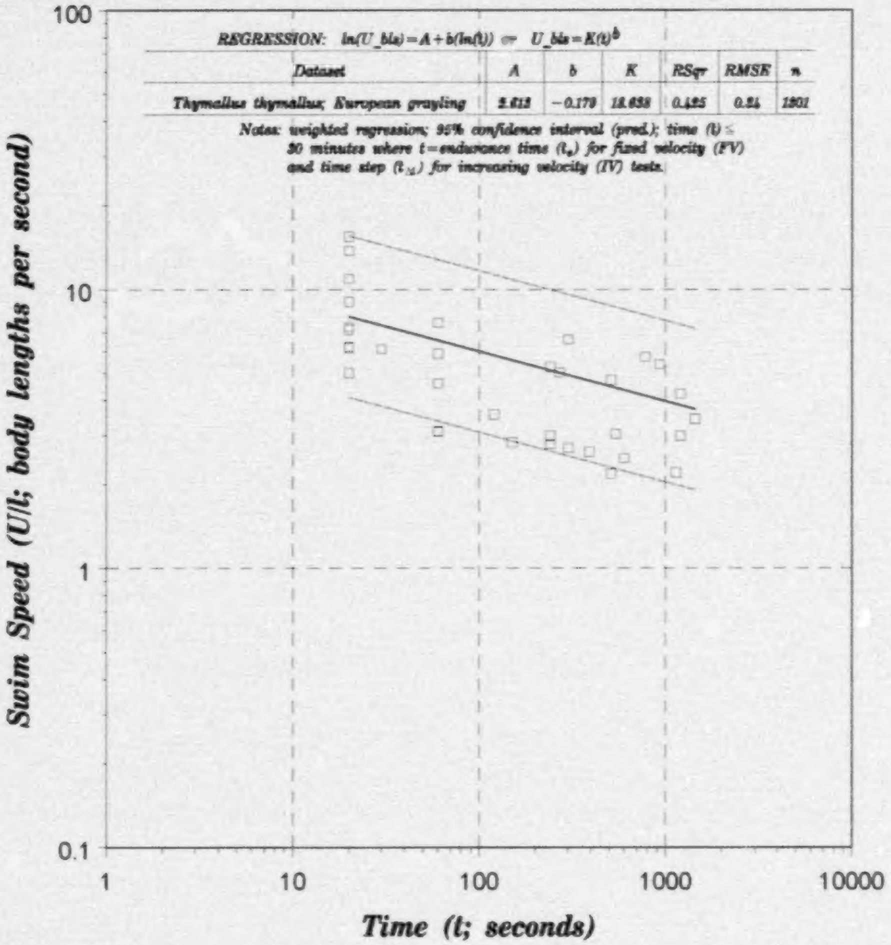


Figure B-122. Processed data for Thymallus thymallus *(European Grayling): time-to-fatigue versus swim speed (body lengths per second). Blue squares are data from Clough et al. (2003).*

Table B-122. Data summary. Fish count 1301, record count 34.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.166	0.083	0.082	0.312	0.23	31
T (C)	13.1	4	5.8	20.9	15.1	25
U (m/s)	0.946	0.525	0.37	1.907	1.537	16
t_e (s)	610	450	30	1440	1410	16
$t_{\Delta t}$ (s)	20	0	20	20	0	1

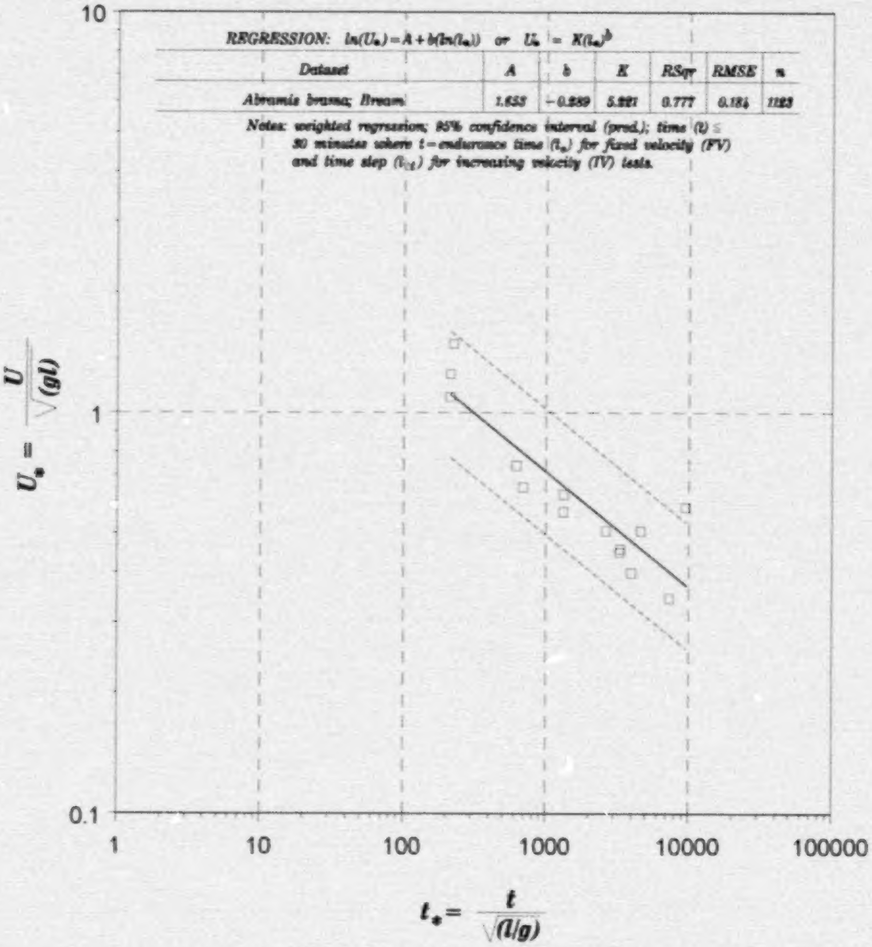
APPENDIX 1–SERIES C

Processed Endurance Data

Dimensionless Swim Speed (U_*) vs Dimensionless Time-to-Fatigue (t_*)

Plotted by Species and Reference (122 graphs)

- This series of graphs uses the same processed swimming speed and time-to-fatigue data found in Appendix A - Series B with data plotted by species (scientific name) and reference (data source) using dimensionless variables for swim speed on the y-axis and time-to-fatigue on x-axis using logarithmic scales. Common names for species are included on the graphs.
- Details about dimensionless analysis are provided in the report.
- This series of plots includes regression lines fitted through the data and the corresponding regression equation coefficients. The 95% prediction intervals have also been included on the plots.
- Regression lines were produced automatically. For some graphs the regression lines are not included as there were insufficient data.



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Abramis brama; Bream	1.653	−0.289	5.221	0.777	0.184	1123

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure C-001. Processed endurance data for Abramis brama *(Bream): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Clough et al. (2003).*

Table C-001. Data summary. Fish count 1123, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.082	0.003	0.074	0.093	0.019	10
T (C)	12.4	5.1	5.9	19.3	13.4	14
U (m/s)	0.563	0.278	0.305	1.31	1.005	10
t_e (s)	358	200	60	840	780	8
$t_{\Delta t}$ (s)	20	0	20	20	0	1

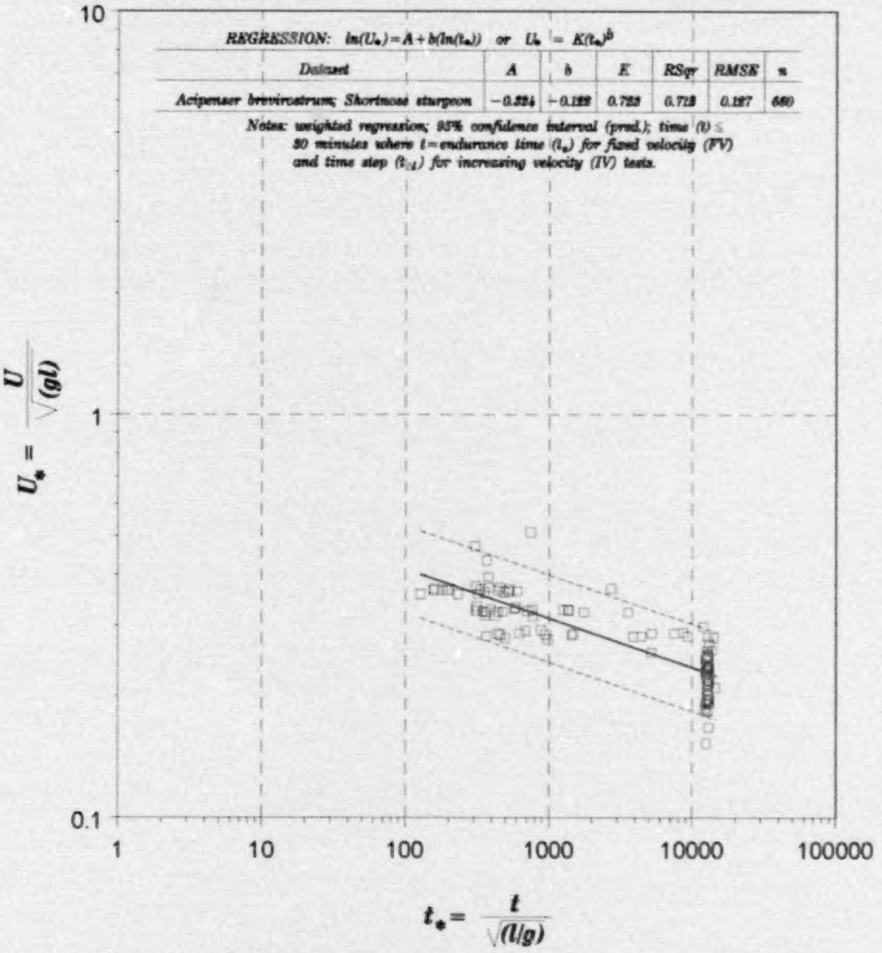


Figure C-002. Processed endurance data for Acipenser brevirostrum *(Shortnose Sturgeon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Deslauriers (2011).*

Table C-002. Data summary. Fish count 660, record count 130.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.163	0.032	0.066	0.211	0.145	47
T (C)	15	6.2	5	25	20	5
U (m/s)	0.358	0.065	0.21	0.45	0.24	52
t_e (s)	206	383	16	1797	1781	62
$t_{\Delta t}$ (s)	1786	92	1200	1800	600	2

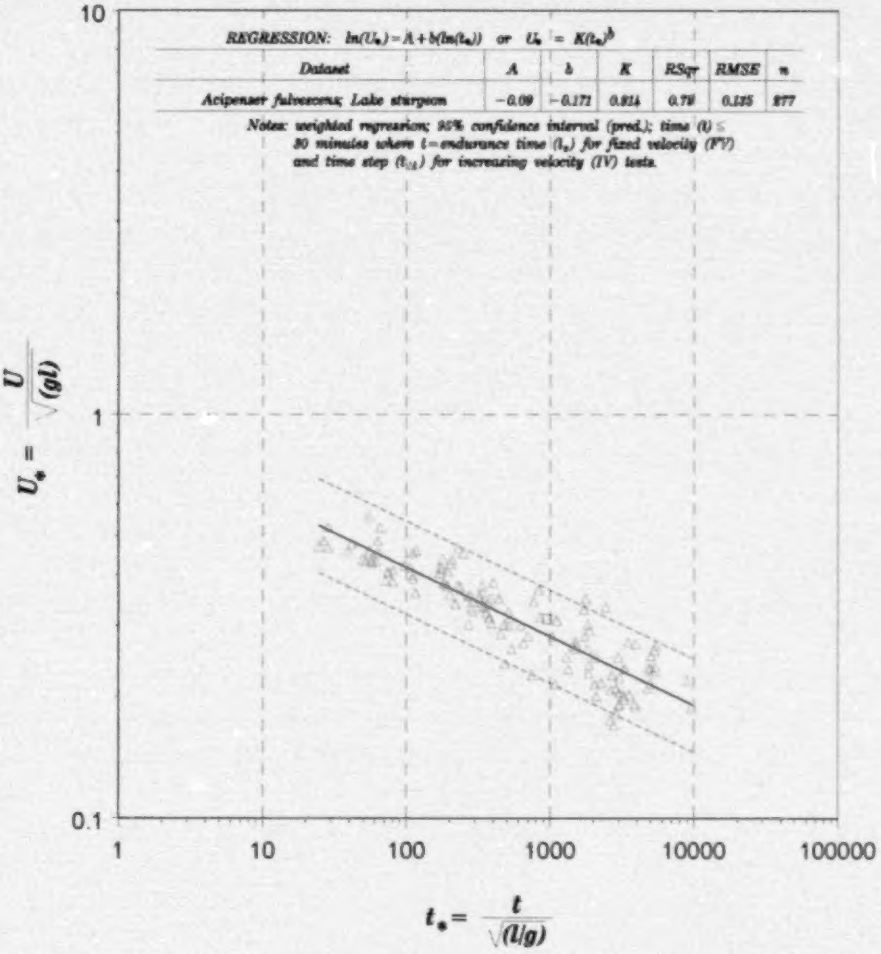


Figure C-003. Processed endurance data for Acipenser fulvescens *(Lake Sturgeon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Webb (1986); red triangles are data from Peake et al. (1995).*

Table C-003. Data summary. Fish count 227, record count 132.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.372	0.236	0.12	1.32	1.2	64
T (C)	13.4	4.9	7	21	14	4
U (m/s)	0.592	0.283	0.258	1.8	1.542	40
t_e (s)	154	264	4	1662	1658	78
$t_{\Delta t}$ (s)	538	162	120	600	480	2

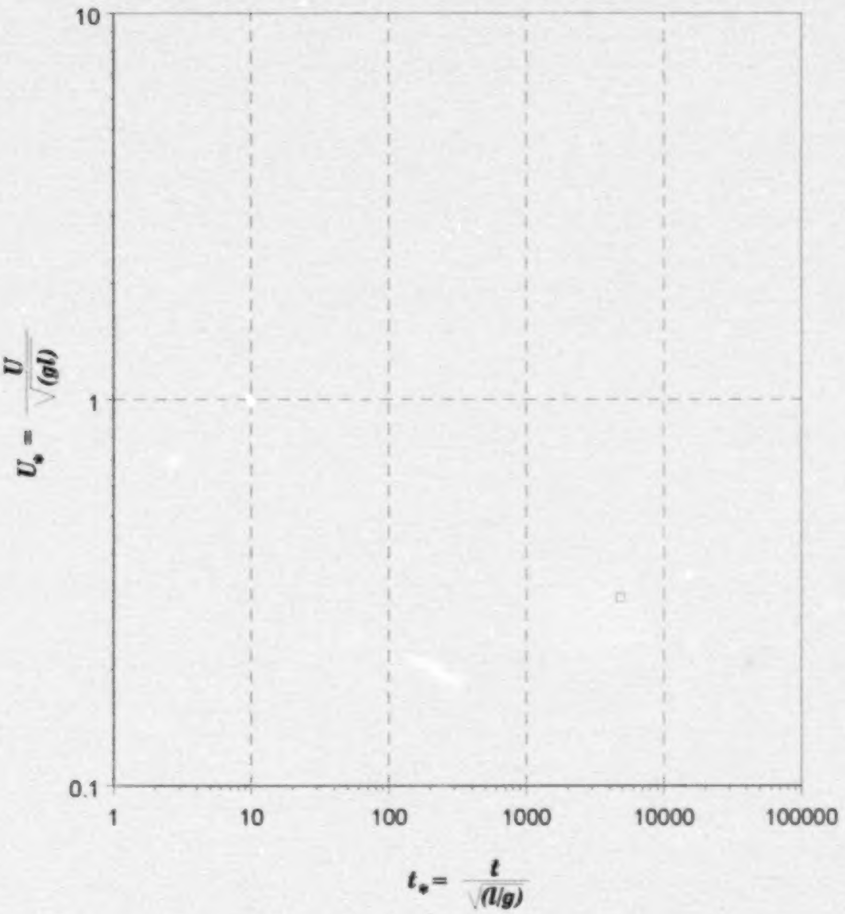


Figure C-004. Processed endurance data for Acipenser transmontanus *(White Surgeon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Counhihan and Frost (1999).*

Table C-004. Data summary. Fish count 14, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.342	0	0.342	0.342	0	1
T (C)	12	0	12	12	0	1
U (m/s)	0.564	0	0.564	0.564	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	900	0	900	900	0	1

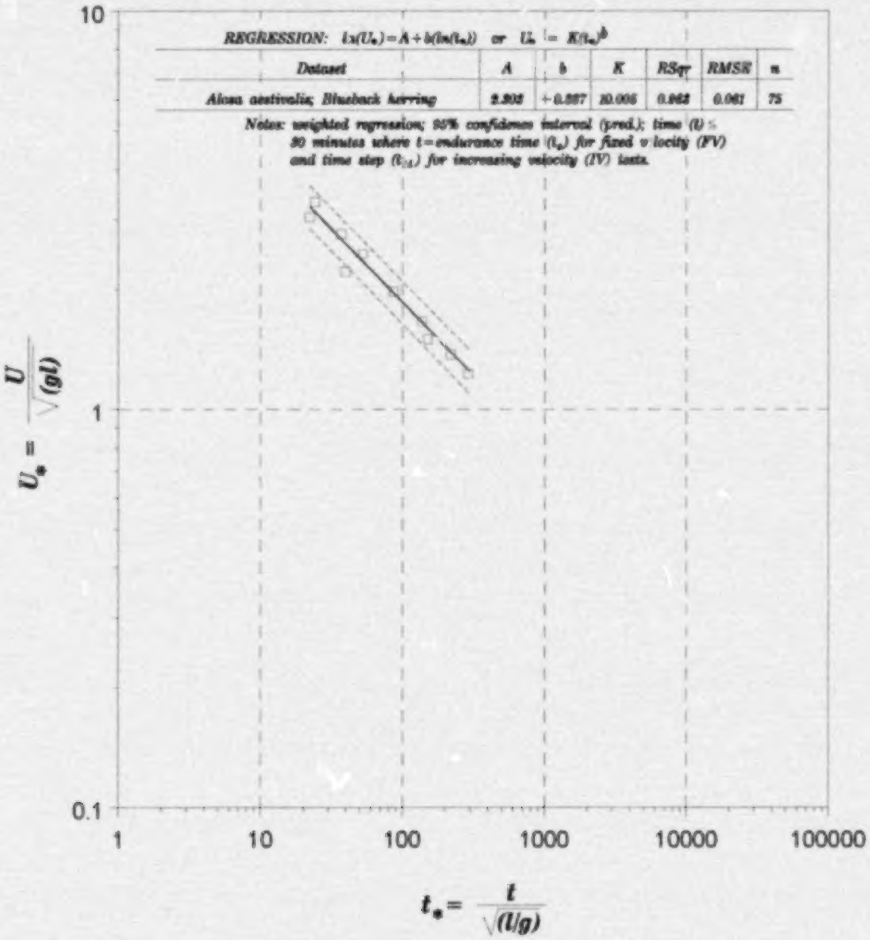


Figure C-005. Processed endurance data for Alosa aestivalis *(Blueback Herring): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Castro-Santos (2005).*

Table C-005. Data summary. Fish count 75, record count 10.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.219	0	0.219	0.219	0	3
T (C)	16.9	0	16.9	16.9	0	1
U (m/s)	3.548	0.971	1.799	4.87	3.071	10
t_e (s)	14	13	3	43	40	10
$t_{\Delta t}$ (s)	.	.	.	.	.	0

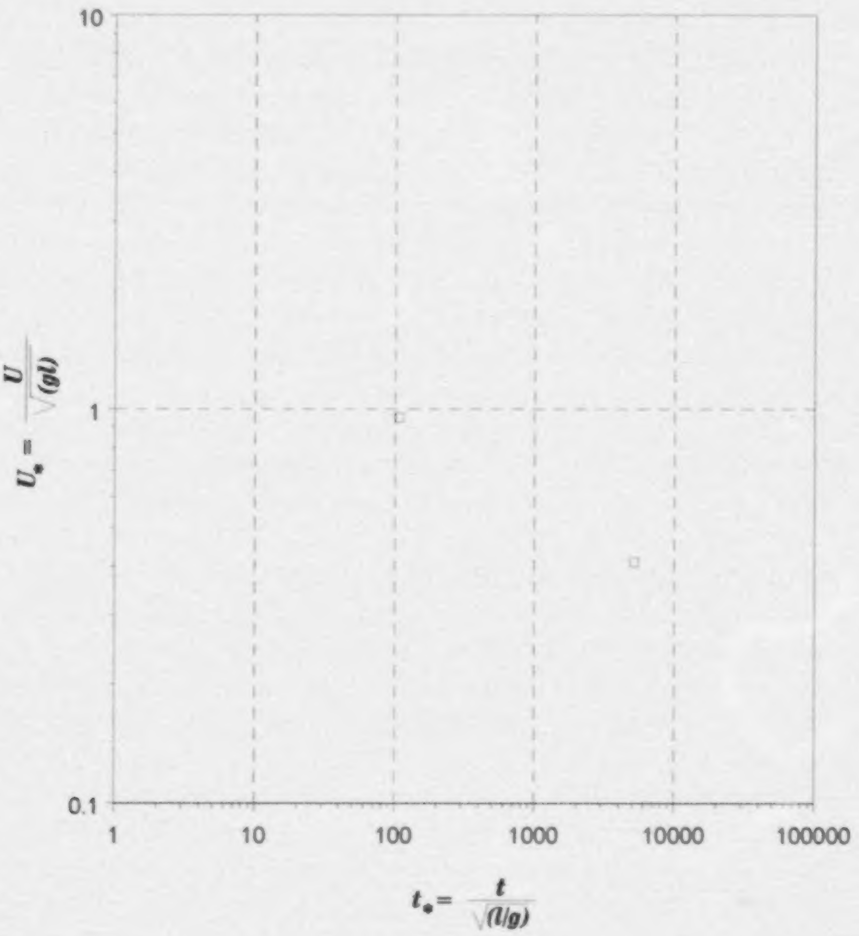


Figure C-006. Processed endurance data for Alosa fallax *(Twaite Shad): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Clough et al. (2004).*

Table C-006. Data summary. Fish count 19, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.335	0.004	0.333	0.341	0.008	2
T (C)	18.9	2.6	14.6	20.4	5.8	2
U (m/s)	1.465	0.439	0.75	1.721	0.971	2
t_e (s)	960	0	960	960	0	1
$t_{\Delta t}$ (s)	20	0	20	20	0	1

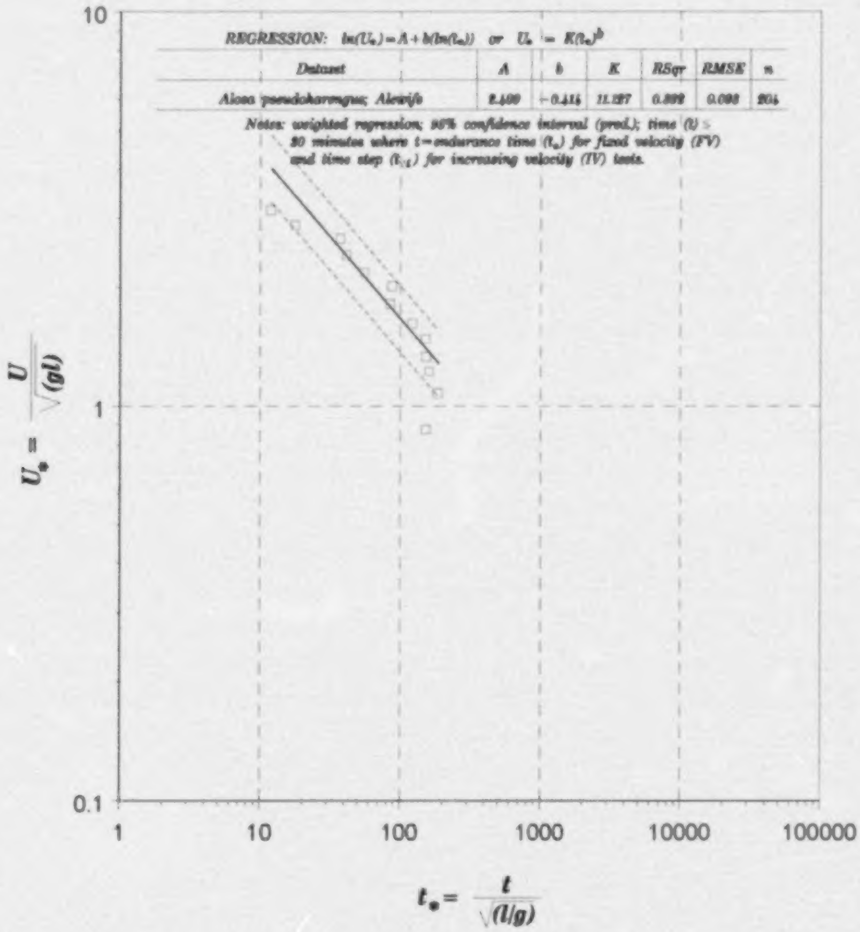


Figure C-007. Processed endurance data for Alosa pseudoharengus *(Alewife): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Castro-Santos (2005).*

Table C-007. Data summary. Fish count 204, record count 13.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.237	0	0.237	0.237	0	3
T (C)	10.4	0	10.4	10.4	0	1
U (m/s)	2.89	0.835	1.33	4.795	3.465	13
t_e (s)	15	8	2	29	27	13
$t_{\Delta t}$ (s)	-	-	-	-	-	0

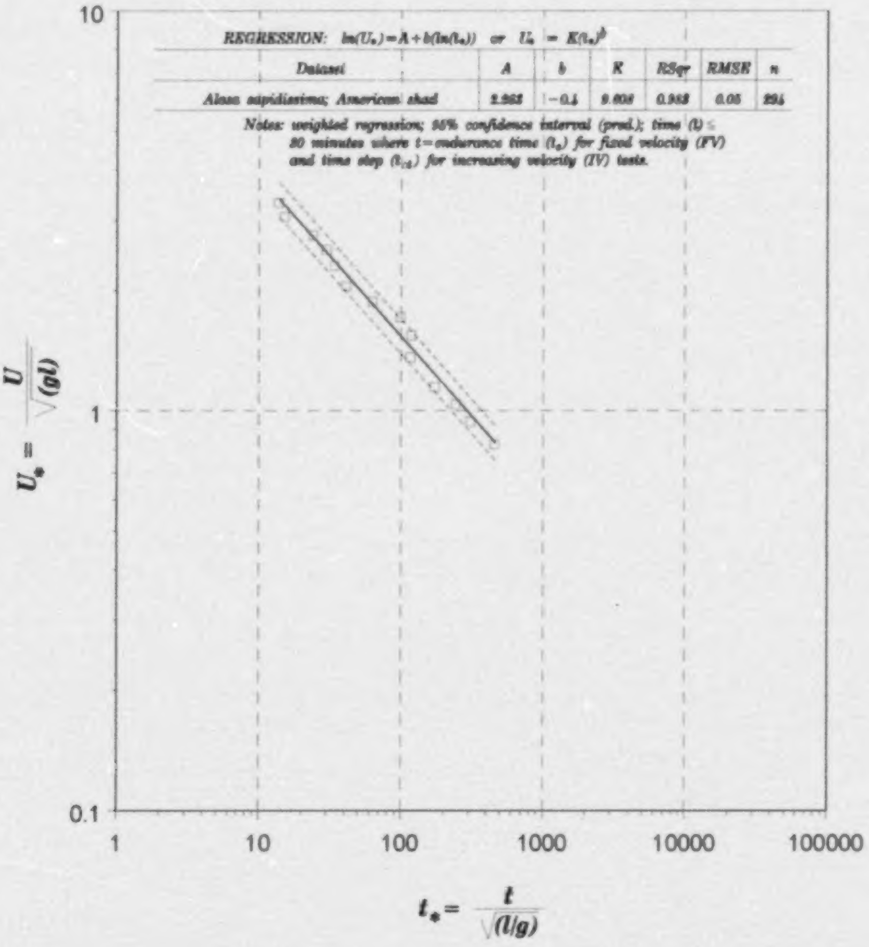


Figure C-008. Processed endurance data for Alosa sapidissima *(American Shad): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Castro-Santos (2005).*

Table C-008. Data summary. Fish count 294, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.418	0	0.418	0.418	0	1
T (C)	18.3	0	18.3	18.3	0	1
U (m/s)	3.945	1.359	1.669	6.71	5.041	14
t_e (s)	21	22	3	94	91	14
$t_{\Delta t}$ (s)	.	.	.	.	.	0

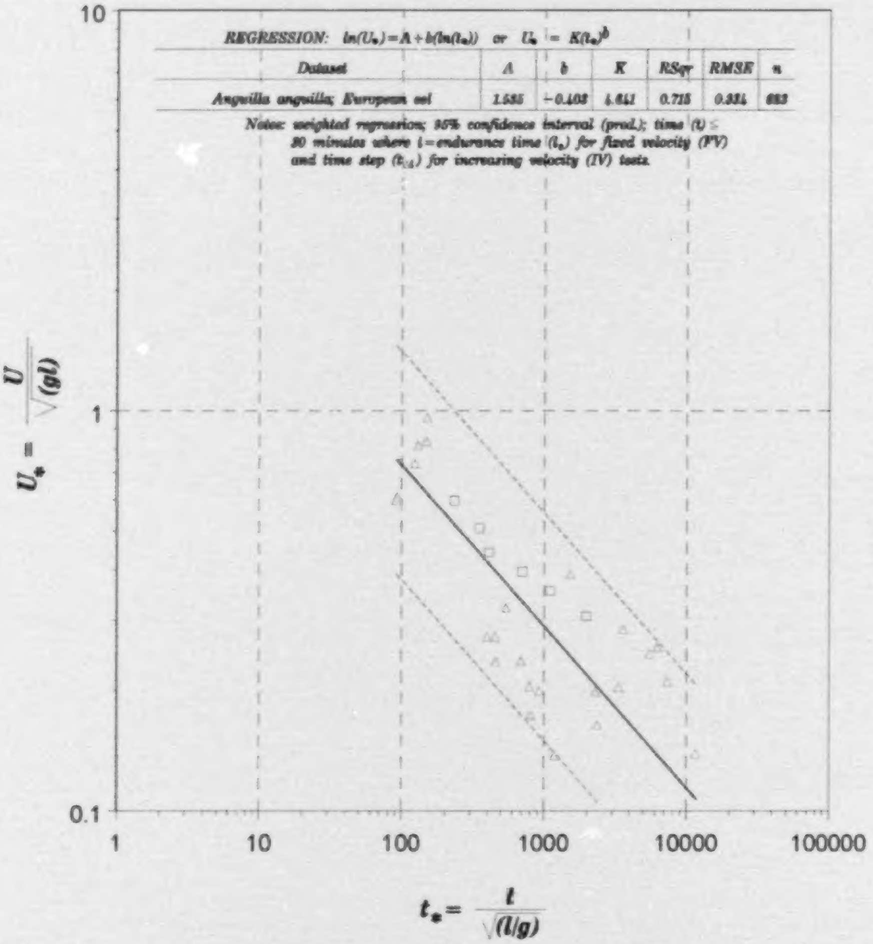


Figure C-009. Processed endurance data for Anguilla anguilla *(European Eel): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from McCleeve (1980); red triangles are data from Clough et al. (2003).*

Table C-009. Data summary. Fish count 623, record count 30.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.26	0.143	0.072	0.57	0.498	24
T (C)	15.3	3.6	10.2	23.5	13.3	17
U (m/s)	0.759	0.442	0.205	1.284	1.079	22
t_e (s)	302	437	20	1740	1720	16
$t_{\Delta t}$ (s)	20	0	20	20	0	1

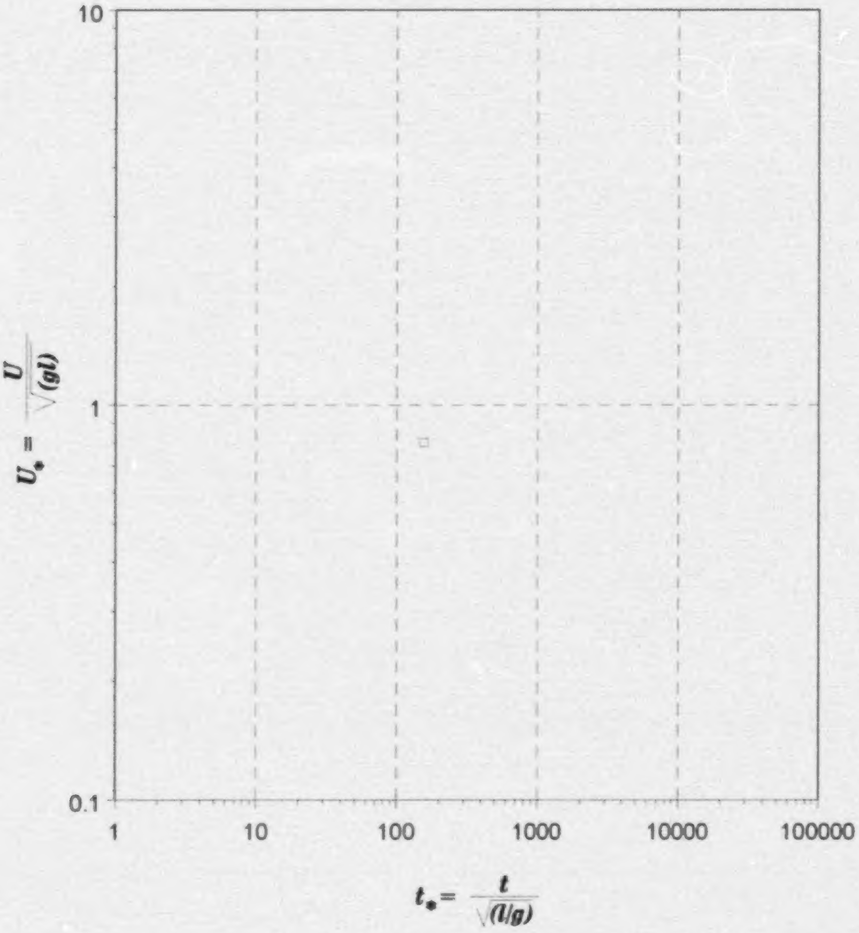


Figure C-010. Processed endurance data for Astyanax mexicanus *(Mexican Tetra): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-010. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.041	0	0.041	0.041	0	1
T (C)	24.9	0	24.9	24.9	0	1
U (m/s)	0.509	0	0.509	0.509	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

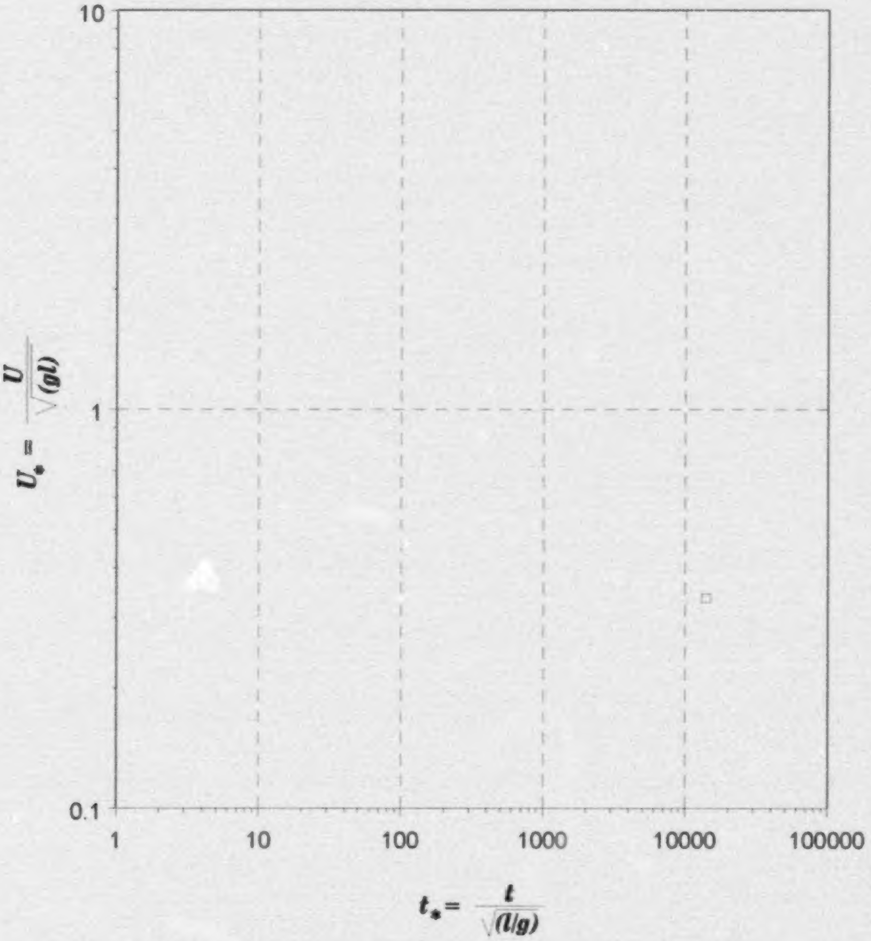


Figure C-011. Processed endurance data for Barbatula barbatula *(Stone Loach):dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Tudorache et al. (2008).*

Table C-011. Data summary. Fish count 8, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.072	0	0.072	0.072	0	1
T (C)	15	0	15	15	0	1
U (m/s)	0.283	0	0.283	0.283	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

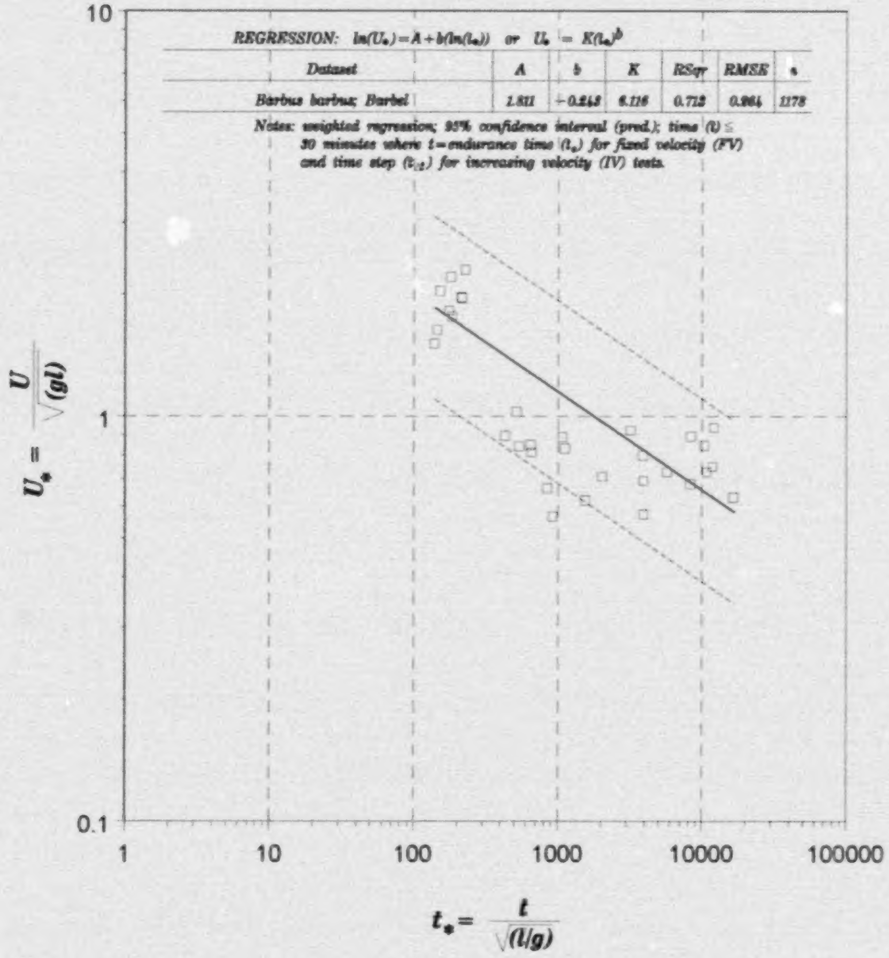


Figure C-012. Processed endurance data for Barbus barbus *(Barbel): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Clough et al. (2003).*

Table C-012. Data summary. Fish count 1178, record count 32.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.123	0.042	0.075	0.205	0.13	28
T (C)	13.1	4.1	7.3	22.9	15.6	24
U (m/s)	1.387	0.682	0.575	2.635	2.06	21
t_e (s)	636	504	60	1560	1500	13
$t_{\Delta t}$ (s)	20	0	20	20	0	1

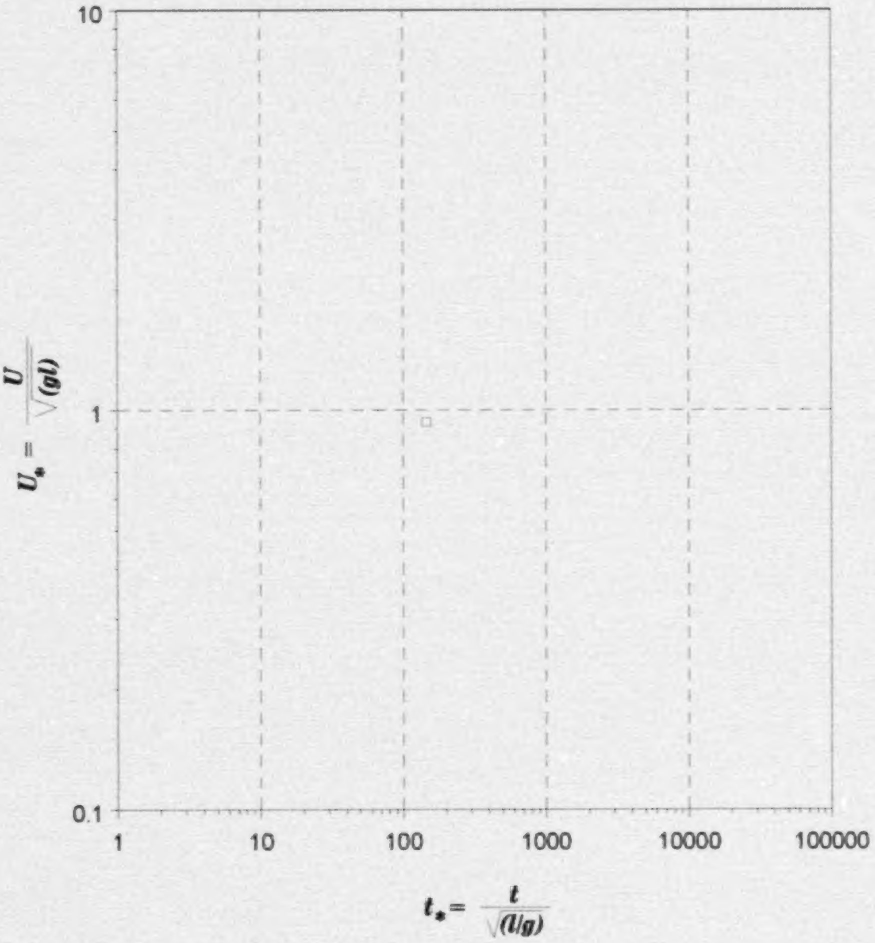
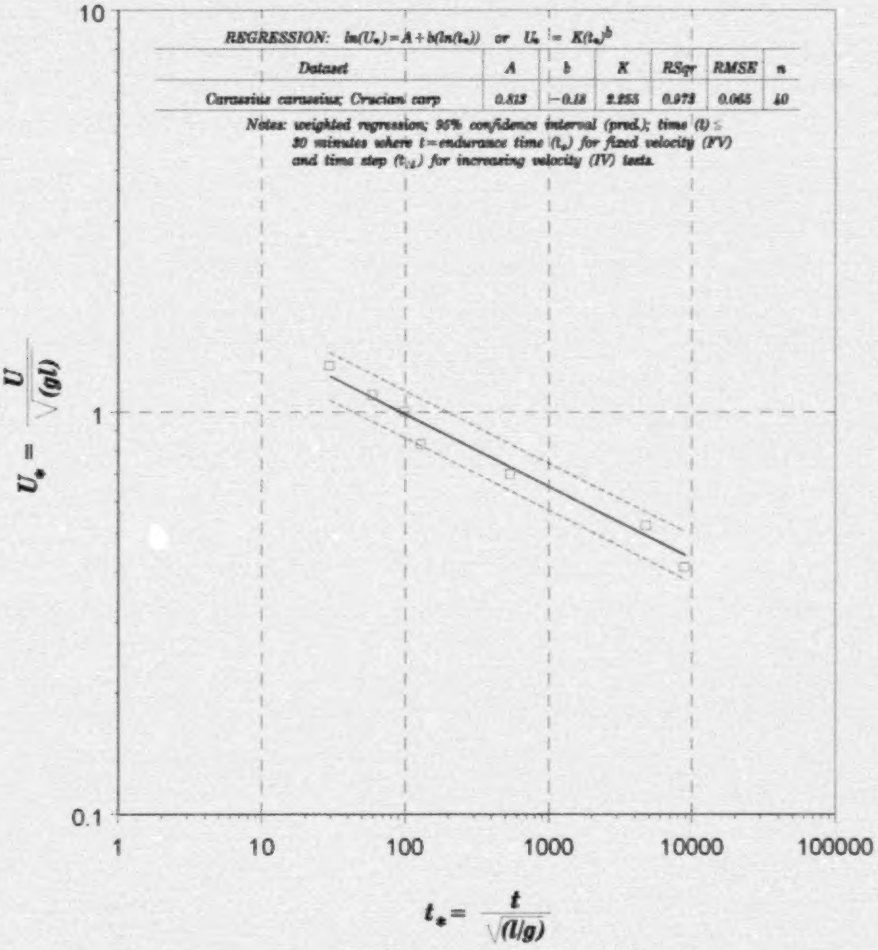


Figure C-013. Processed endurance data for Campostoma anomalum *(Central Stoneroller): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-013. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.046	0	0.046	0.046	0	1
T (C)	28.2	0	28.2	28.2	0	1
U (m/s)	0.629	0	0.629	0.629	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Carassius carassius; Crucian carp	0.813	−0.18	2.255	0.973	0.065	40

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure C-014. Processed endurance data for Carassius carassius *(Crucian Carp): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Tsukamoto et al. (1975).*

Table C-014. Data summary. Fish count 40, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.101	0	0.101	0.101	0	1
T (C)	13	0	13	13	0	1
U (m/s)	0.798	0.3	0.41	1.3	0.89	7
t_e (s)	245	321	3	900	897	7
$t_{\Delta t}$ (s)	.	.	.	.	.	0

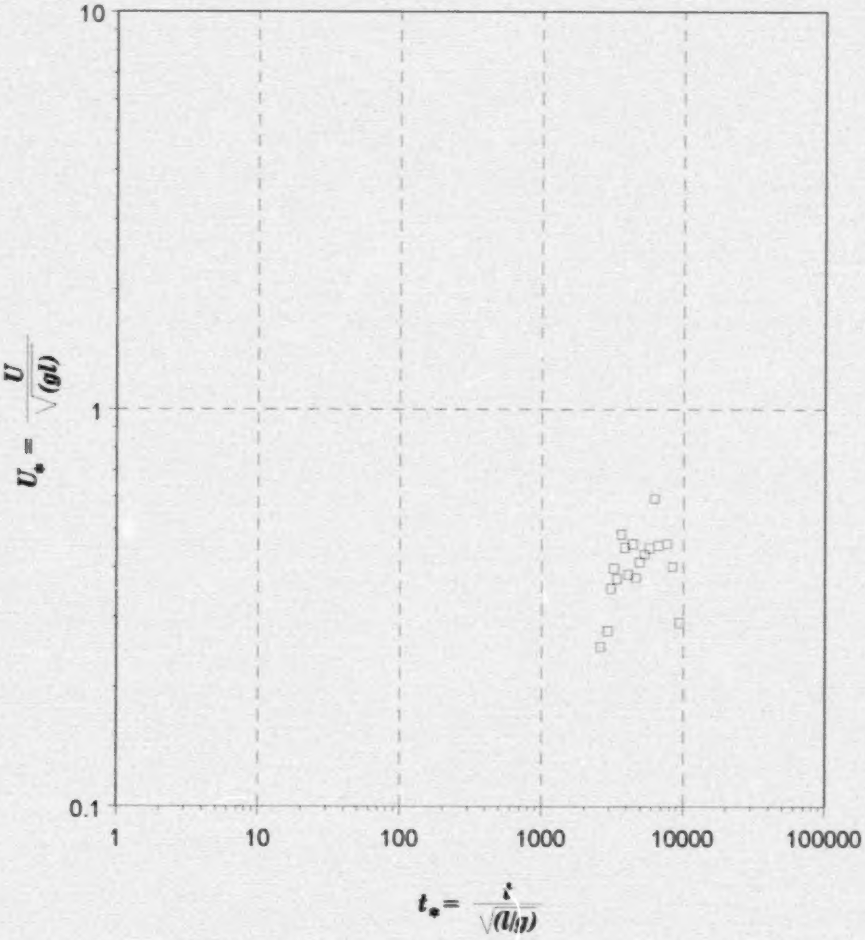


Figure C-015. Processed endurance data for Catostomus catostomus *(Longnose Sucker): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973).*

Table C-015. Data summary. Fish count 150, record count 18.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.22	0.112	0.04	0.52	0.48	18
T (C)	13.5	0	13.5	13.5	0	1
U (m/s)	0.568	0.154	0.182	0.78	0.598	18
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

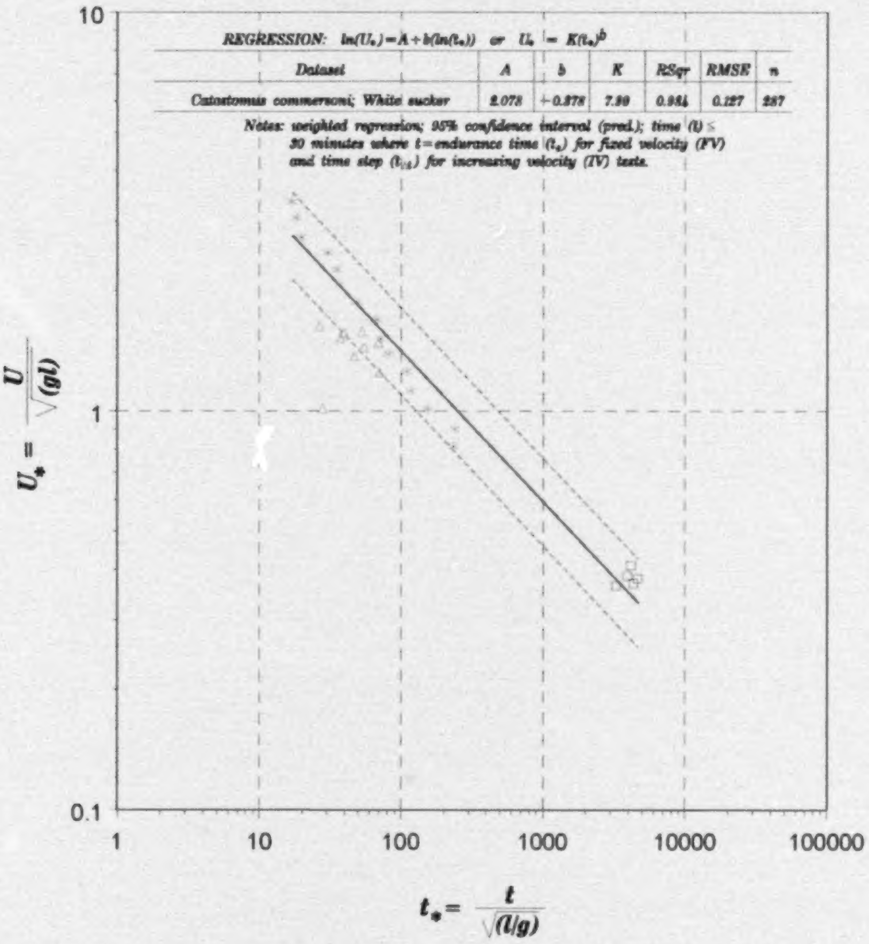


Figure C-016. Processed endurance data for Catostomus commersoni *(White Sucker): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973); red triangles are data from McAuley (1996); green stars are data from Castro-Santos (2005).*

Table C-016. Data summary. Fish count 287, record count 29.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.383	0.051	0.165	0.5	0.335	14
T (C)	14.2	1.5	10.5	16	5.5	3
U (m/s)	3.612	1.325	0.483	6.587	6.104	29
t_e (s)	11	8	3	48	45	21
$t_{\Delta t}$ (s)	600	0	600	600	0	1

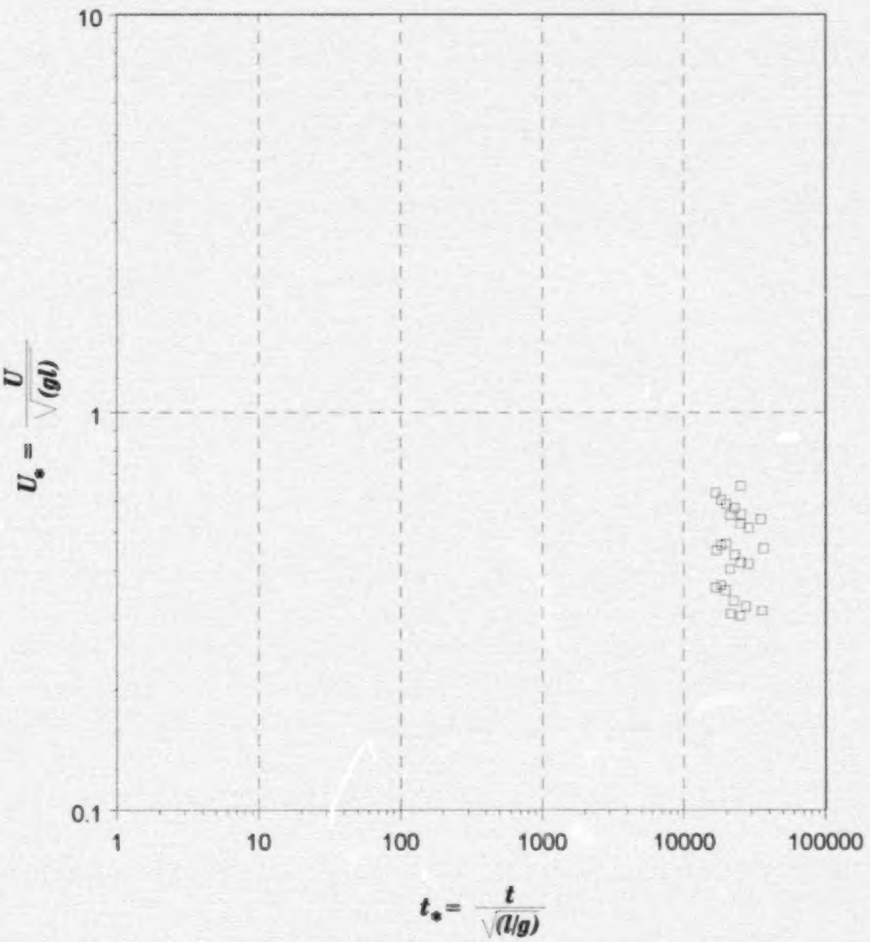


Figure C-017. Processed endurance data for Catostomus laipinnis *(Flannelmouth Sucker): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Ward et al. (2002).*

Table C-017. Data summary. Fish count 588, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.064	0.026	0.024	0.114	0.09	25
T (C)	14.6	4.1	10	20	10	3
U (m/s)	0.351	0.118	0.157	0.663	0.506	25
t_e (s)	1800	0	1800	1800	0	1
$t_{\Delta t}$ (s)	.	.	.	.	.	0

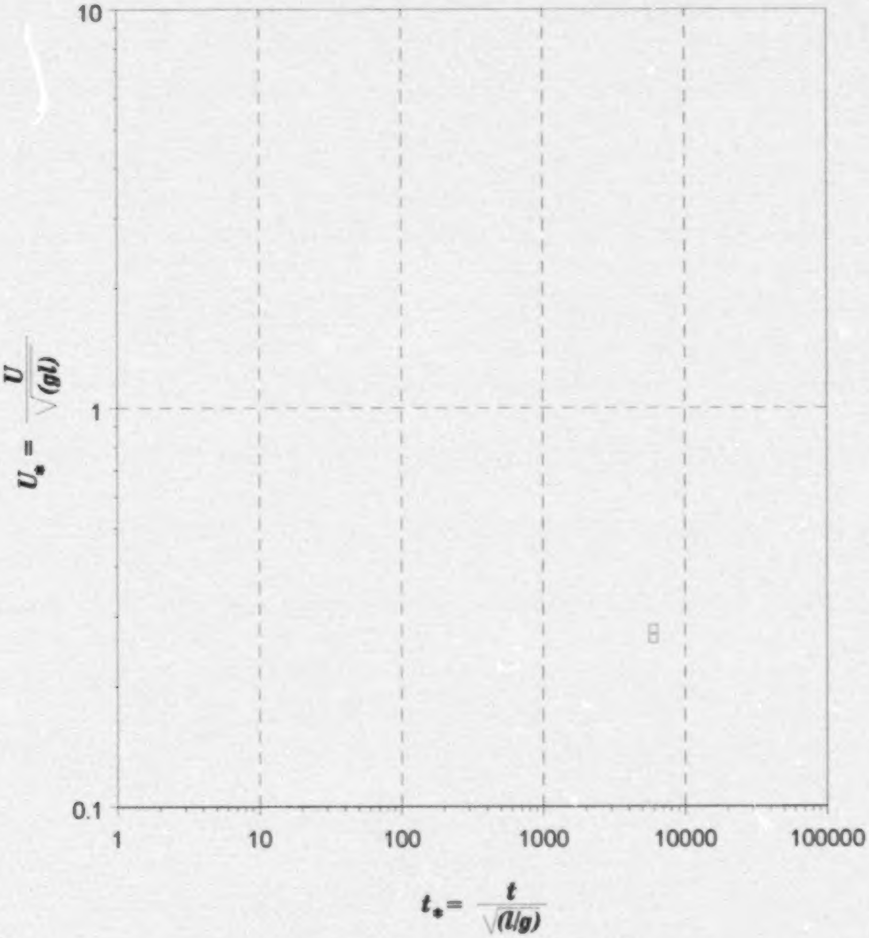


Figure C-018. Processed endurance data for Catostomus macrochellus *(Largescale Sucker): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Kolok et al. (1993).*

Table C-018. Data summary. Fish count 24, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.397	0	0.397	0.397	0	1
T (C)	13	3.1	10	16	6	2
U (m/s)	0.535	0.015	0.52	0.55	0.03	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

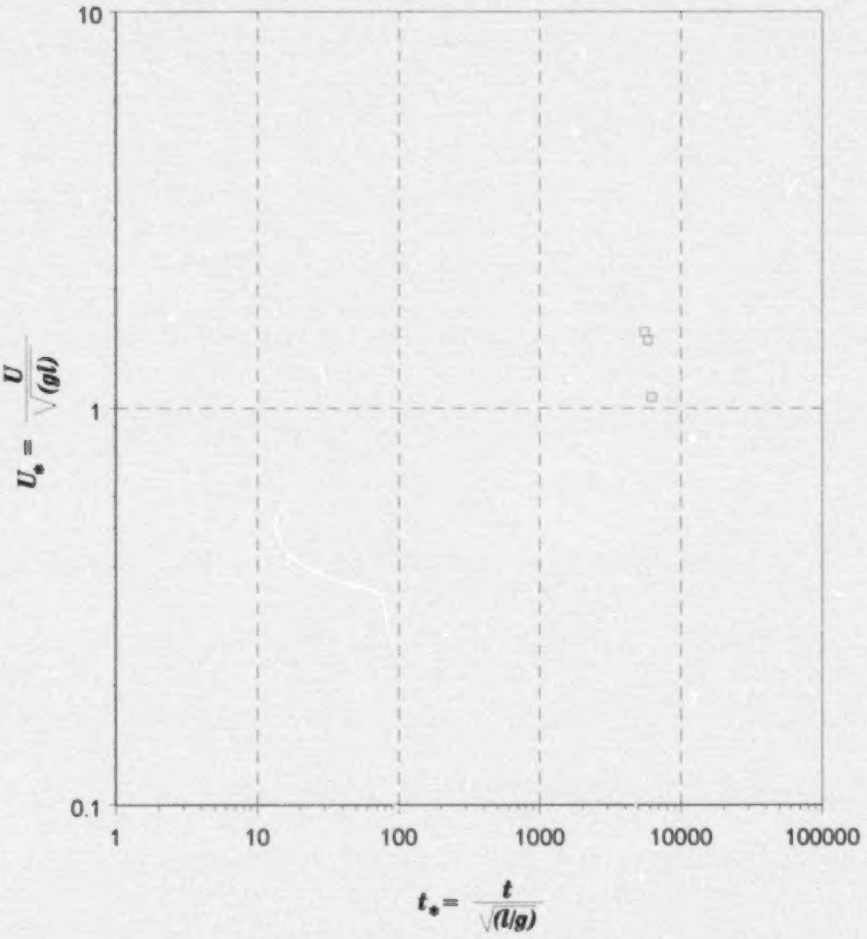


Figure C-019. Processed endurance data for Catostomus platyrhynchus *(Mountain Sucker): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Aedo et al. (2009).*

Table C-019. Data summary. Fish count 14, record count 3.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.025	0.002	0.023	0.029	0.006	3
T (C)	17	0	17	17	0	1
U (m/s)	0.641	0.141	0.507	0.832	0.325	3
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

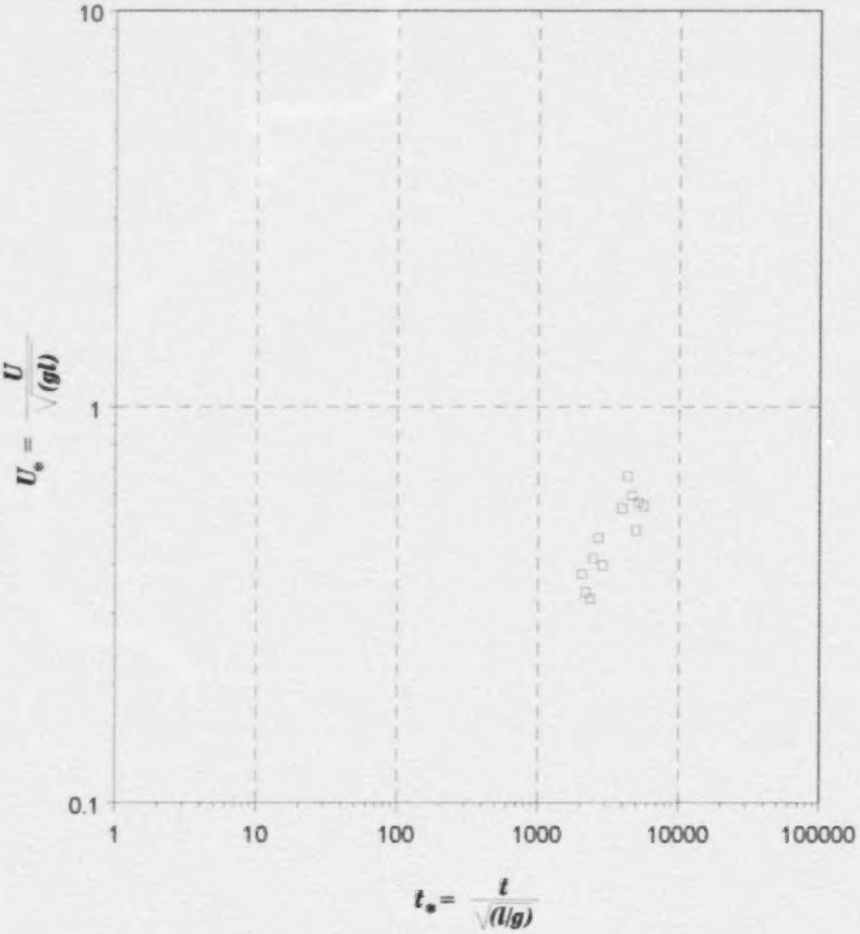


Figure C-020. Processed endurance data for Chasmistes liorus (June Sucker): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Aedo et al. (2009).*

Table C-020. Data summary. Fish count 26, record count 12.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.1	0.061	0.028	0.205	0.177	12
T (C)	17	0	17	17	0	1
U (m/s)	0.42	0.076	0.289	0.536	0.247	12
t_e (s)	-	-	-	-	-	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

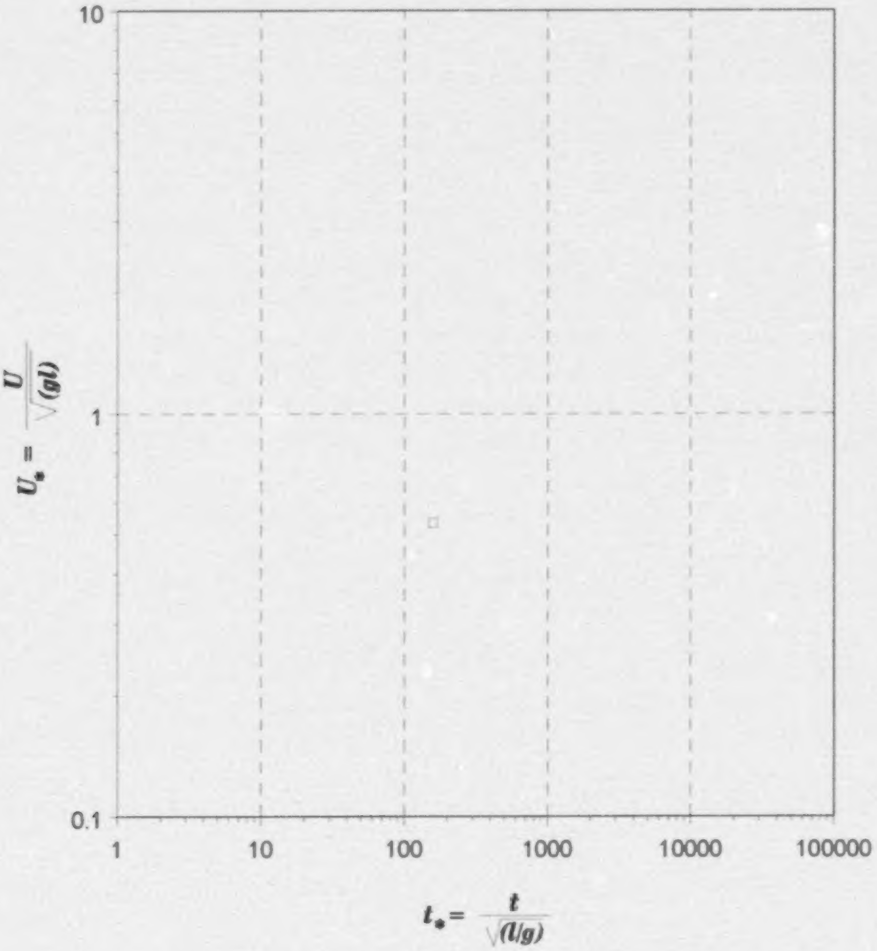


Figure C-021. Processed endurance data for Cichlasoma cyanoguttatum *(Rio Grande Cichlid): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-021. Data summary. Fish count 8, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.039	0	0.039	0.039	0	1
T (C)	25.6	0	25.6	25.6	0	1
U (m/s)	0.33	0	0.33	0.33	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

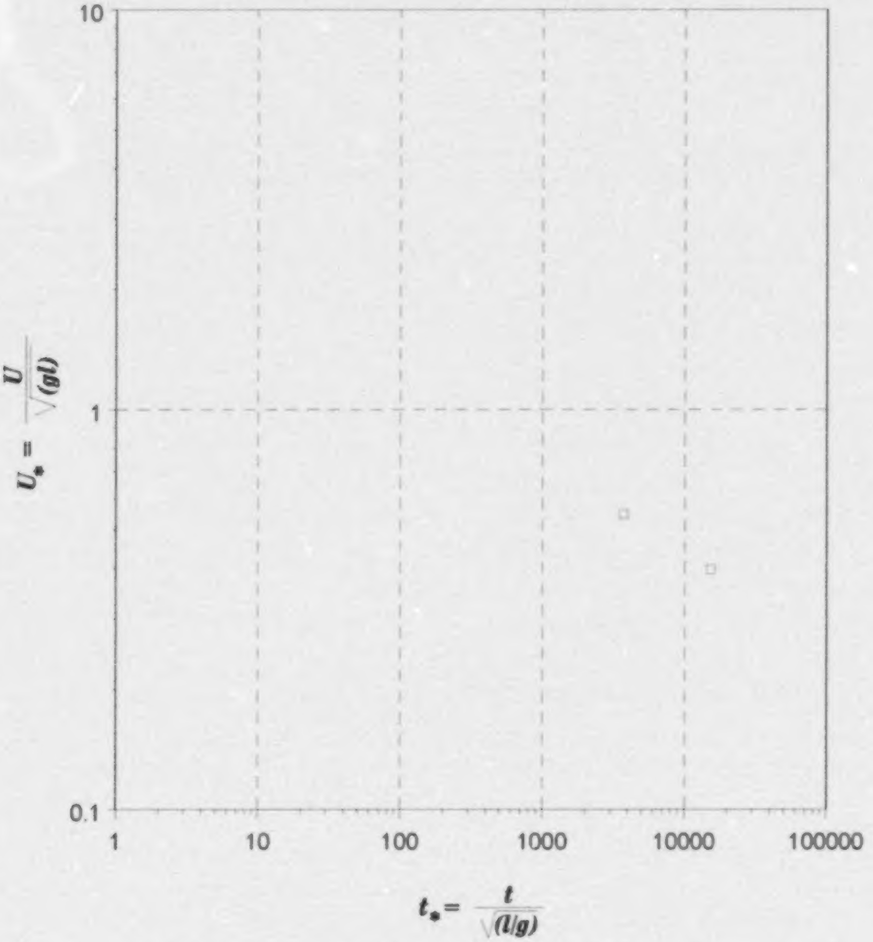


Figure C-022. Processed endurance data for Coregonus artedii *(Cisco): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Bernatchez and Dodson (1985).*

Table C-022. Data summary. Fish count 28, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.135	0	0.135	0.135	0	1
T (C)	12	0	12	12	0	1
U (m/s)	0.581	0.079	0.458	0.63	0.172	2
t_e (s)	438	0	438	438	0	1
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

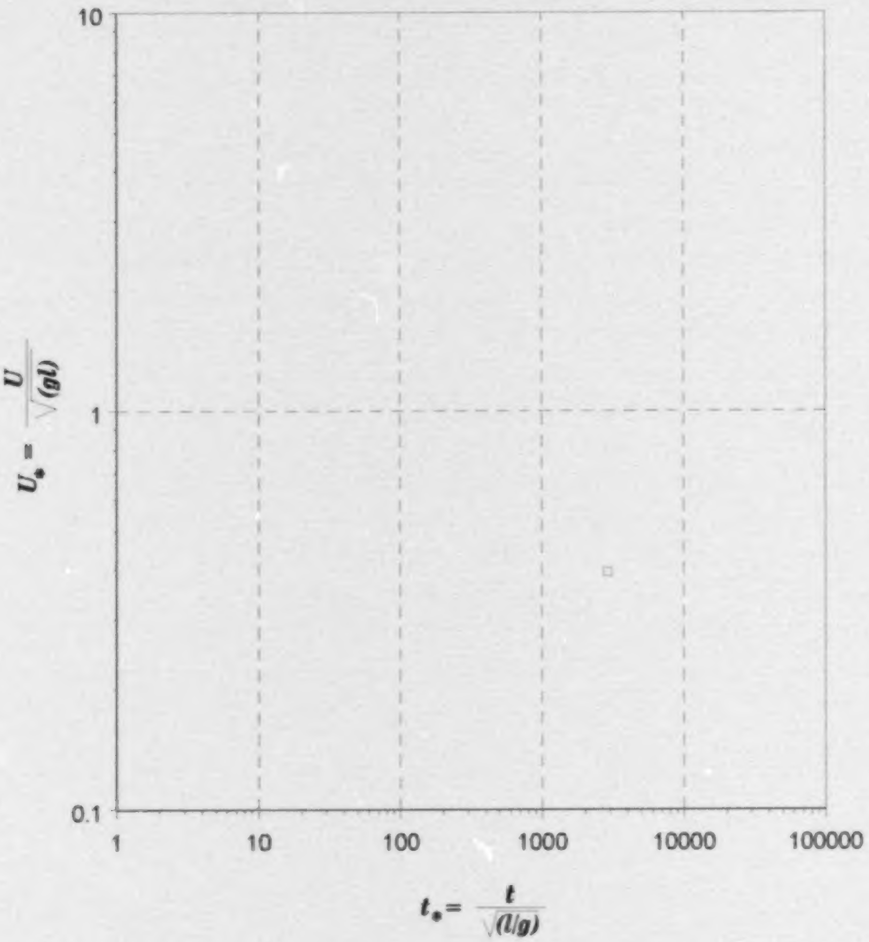


Figure C-023. Processed endurance data for Coregonus autumnalis *(Arctic Cisco): dimensionless swim speed (U^*) versus dimensionless time-to-fatigue (t^*). Blue square is data from Jones et al. (1973).*

Table C-023. Data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.42	0	0.42	0.42	0	1
T (C)	10	0	10	10	0	1
U (m/s)	0.8	0	0.8	0.8	0	1
t_e (s)	-	-	-	-	-	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

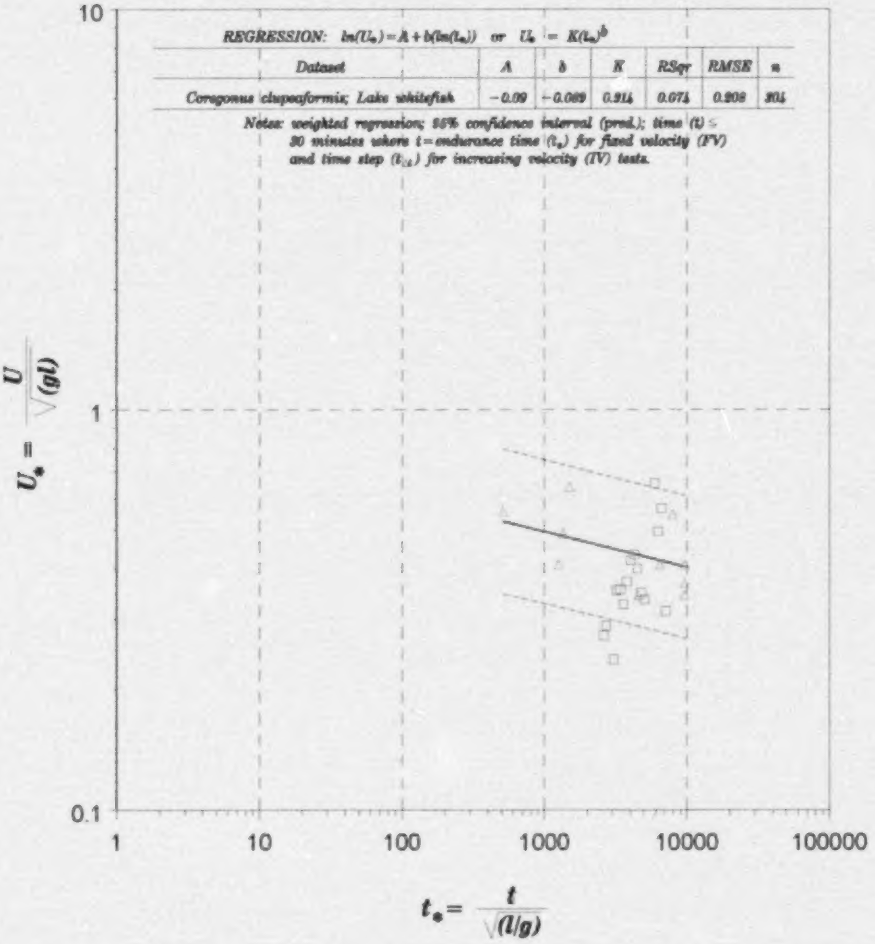


Figure C-024. Processed endurance data for Coregonus clupeaformis (Lake Whitefish): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973); red triangles are data from Bernatchez and Dodson (1985).*

Table C-024. Data summary. Fish count 304, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.216	0.096	0.07	0.52	0.45	18
T (C)	12.3	2.5	5	17	12	4
U (m/s)	0.619	0.13	0.26	1.02	0.76	22
t_e (s)	579	390	96	1200	1104	7
$t_{\Delta t}$ (s)	771	420	600	1800	1200	2

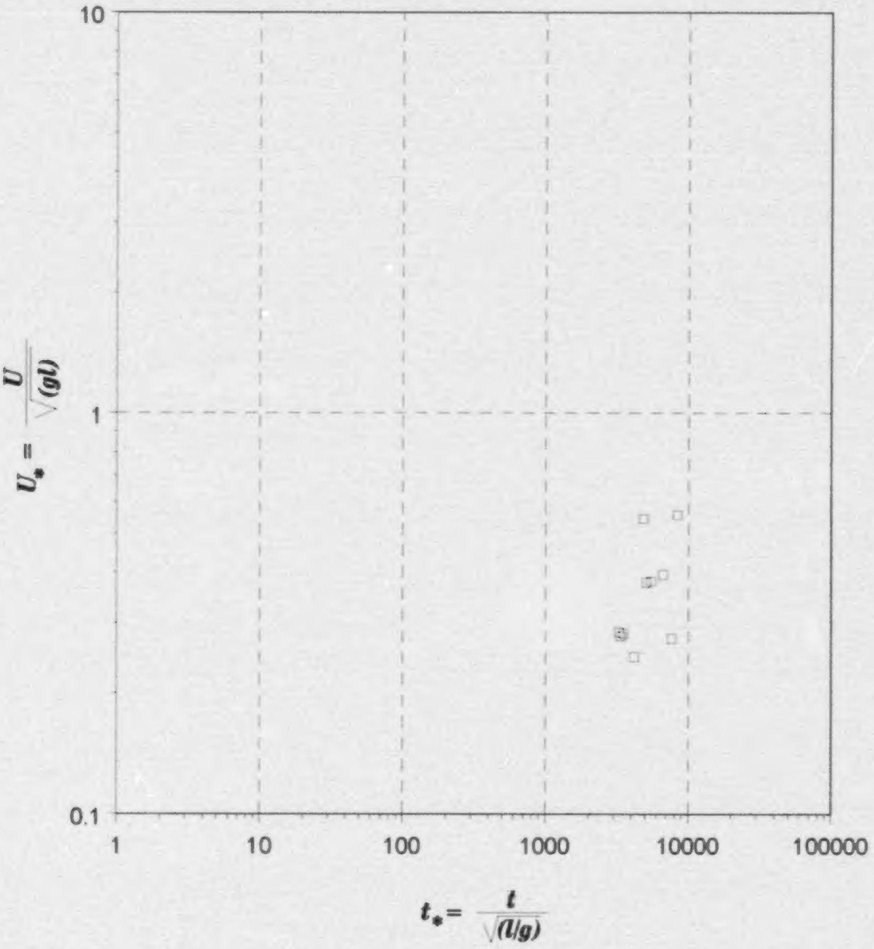


Figure C-025. Processed endurance data for Coregonus nasus *(Broad Whitefish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973).*

Table C-025. Data summary. Fish count 21, record count 10.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.206	0.096	0.05	0.33	0.28	10
T (C)	12.5	0	12.5	12.5	0	1
U (m/s)	0.437	0.086	0.21	0.66	0.45	10
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

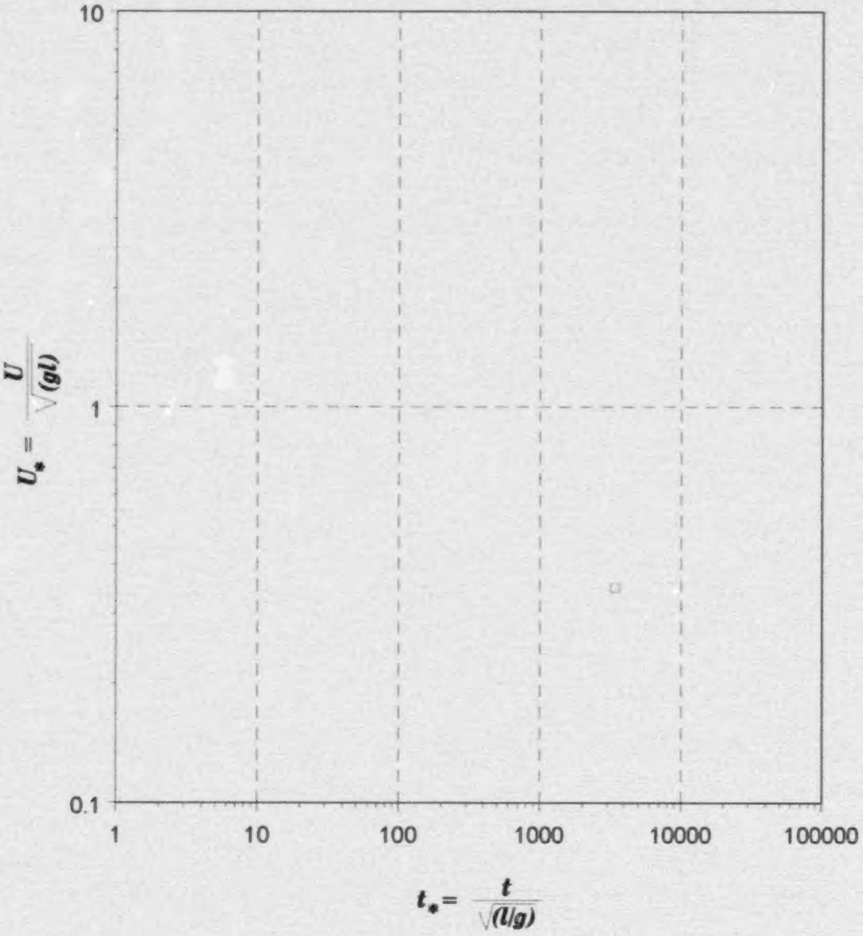


Figure C-026. Processed endurance data for Coregonus sardinella *(Least Cisco): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Jones et al. (1973).*

Table C-026. Data summary. Fish count 2, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0	0.3	0.3	0	1
T (C)	16	0	16	16	0	1
U (m/s)	0.6	0	0.6	0.6	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

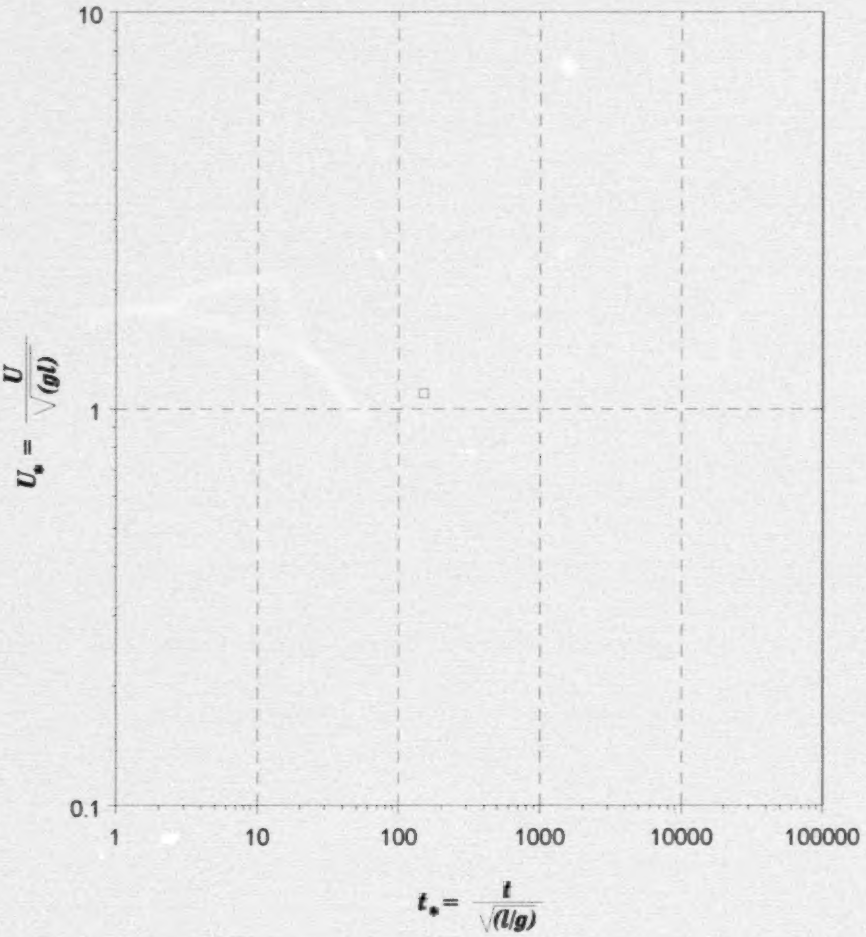


Figure C-027. Processed endurance data for Cyprinella lutrensis *(Red Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-027. Data summary. Fish count 16, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	27.7	0	27.7	27.7	0	1
U (m/s)	0.712	0	0.712	0.712	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

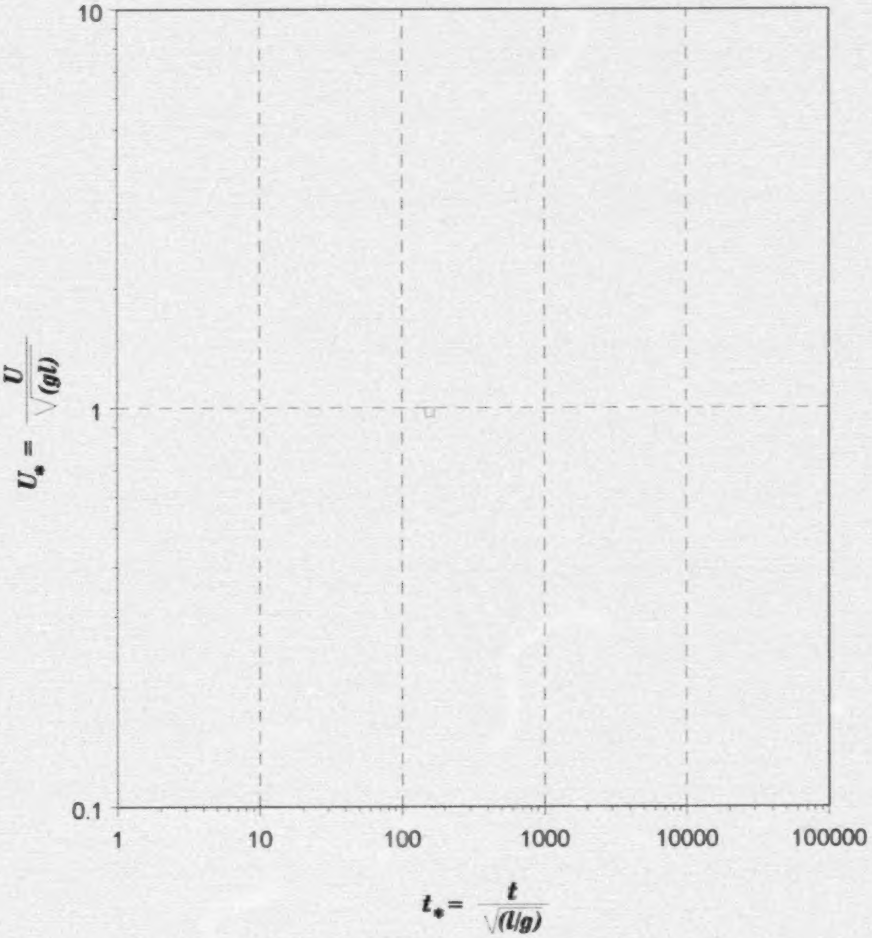


Figure C-028. Processed endurance data for Cyprinella proserpina *(Proserpine Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-028. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0	0.04	0.04	0	1
T (C)	23.5	0	23.5	23.5	0	1
U (m/s)	0.608	0	0.608	0.608	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

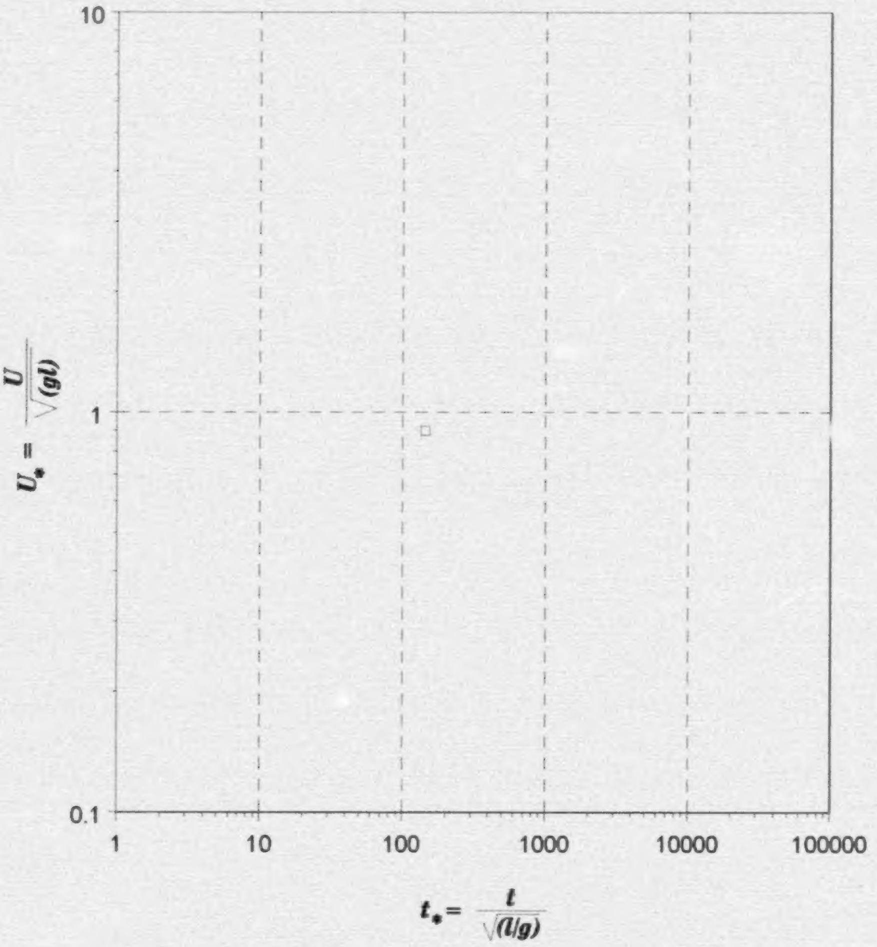


Figure C-029. Processed endurance data for Cyprinella venusta *(Blacktail Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-029. Data summary. Fish count 19, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.047	0	0.047	0.47	0	1
T (C)	23.1	0	23.1	23.1	0	1
U (m/s)	0.611	0	0.611	0.611	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

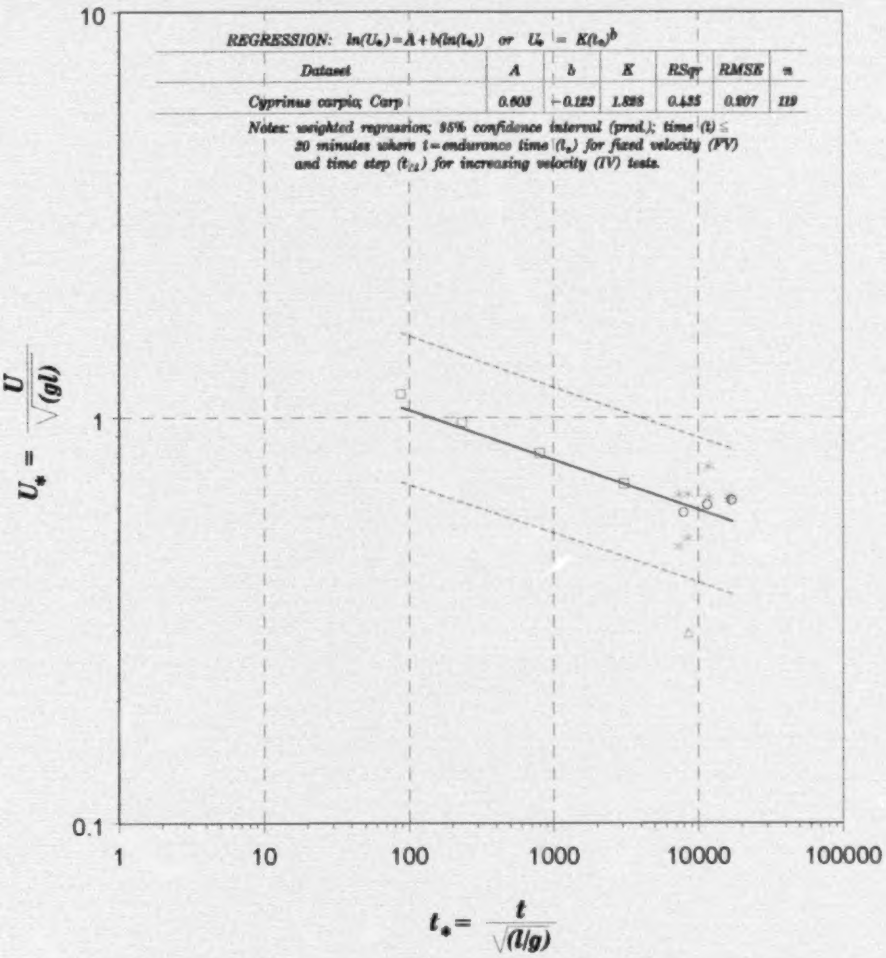


Figure C-030. Processed endurance data for Cyprinus carpio *(Carp): dimensionless swim speed (U^*) versus dimensionless time-to-fatigue (t^*). Blue squares are data from Tsukamoto et al. (1975); red triangles are data from West et al. (1994); green stars are data from Tudorache et al. (2007) and black circles are data from Tudorache et al. (2008).*

Table C-030. Data summary. Fish count 119, record count 16.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.163	0.095	0.049	0.44	0.391	9
T (C)	18.6	3.8	11.5	22	10.5	3
U (m/s)	0.779	0.257	0.433	1.4	0.967	16
t_e (s)	110	141	11	380	369	4
$t_{\Delta t}$ (s)	1238	147	1200	1800	600	2

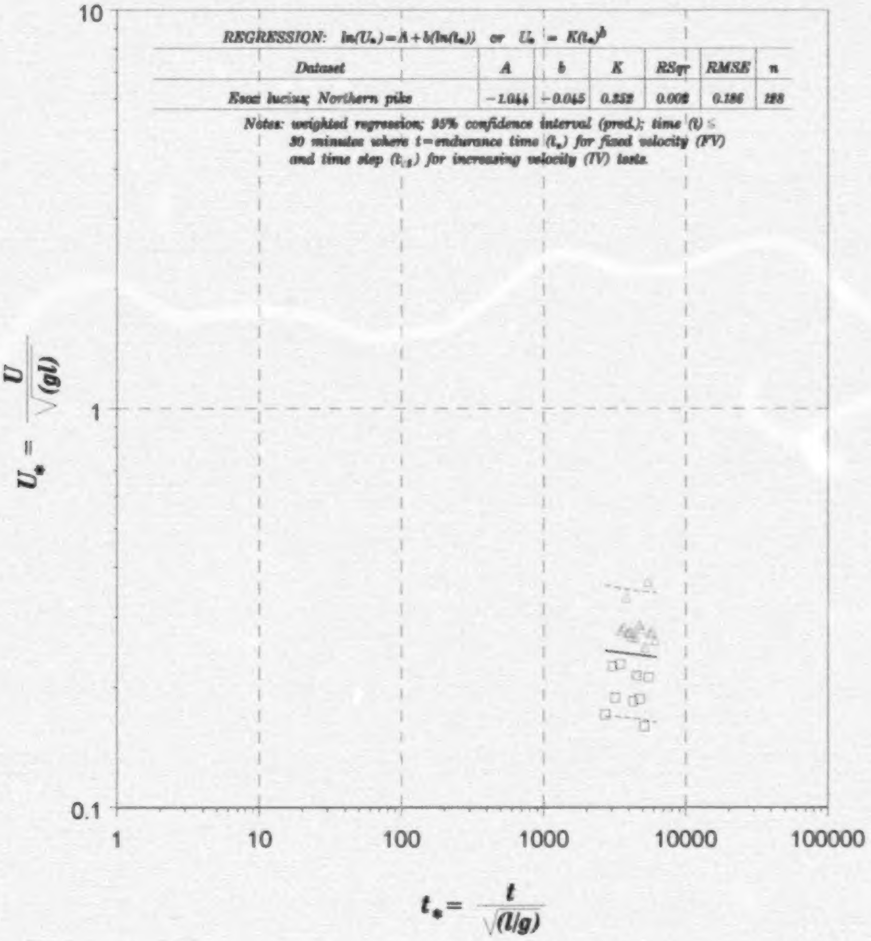


Figure C-031. Processed endurance data for Esox lucius *(Northern Pike): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973); red triangles are data from Peake (2004b).*

Table C-031. Data summary. Fish count 128, record count 25.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.108	0.095	0.024	0.48	0.456	25
T (C)	16.5	3.4	12	19	7	2
U (m/s)	0.221	0.063	0.126	0.435	0.309	23
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	405	144	300	600	300	2

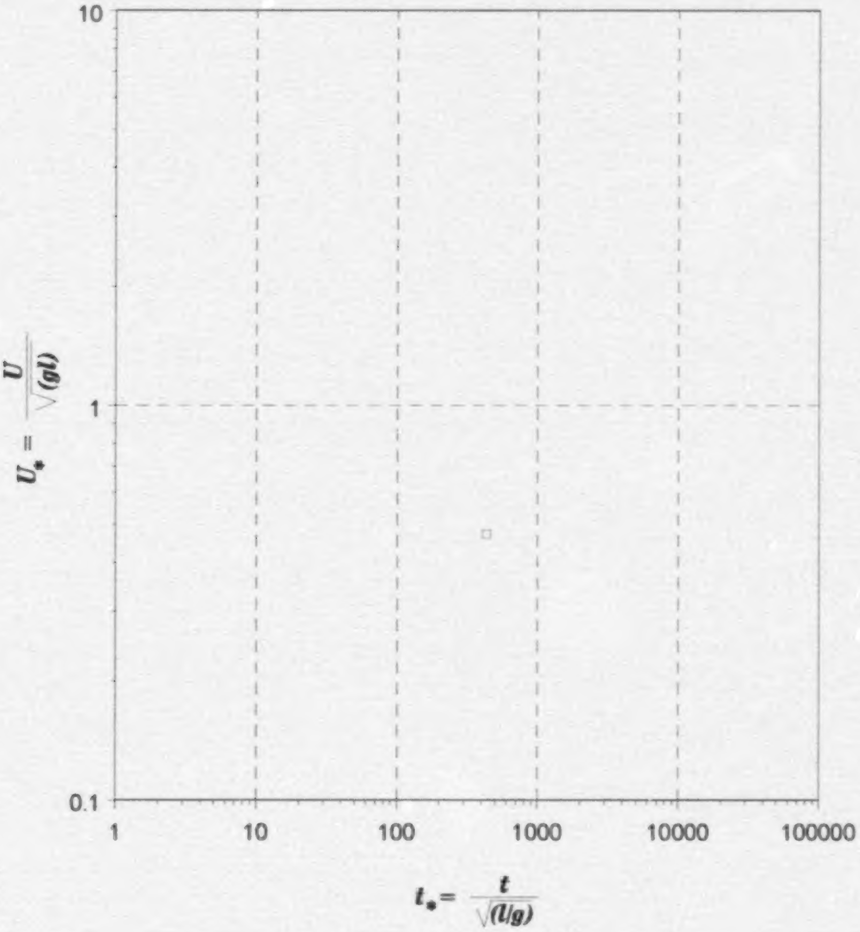


Figure C-032. Processed endurance data for Esox sp. *(Tiger Muskellunge): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Webb et al. (1992).*

Table C-032. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.189	0	0.189	0.189	0	1
T (C)	25	0	25	25	0	1
U (m/s)	0.642	0	0.642	0.642	0	1
t_e (s)	-	-	-	-	-	0
$t_{\Delta t}$ (s)	60	0	60	60	0	1

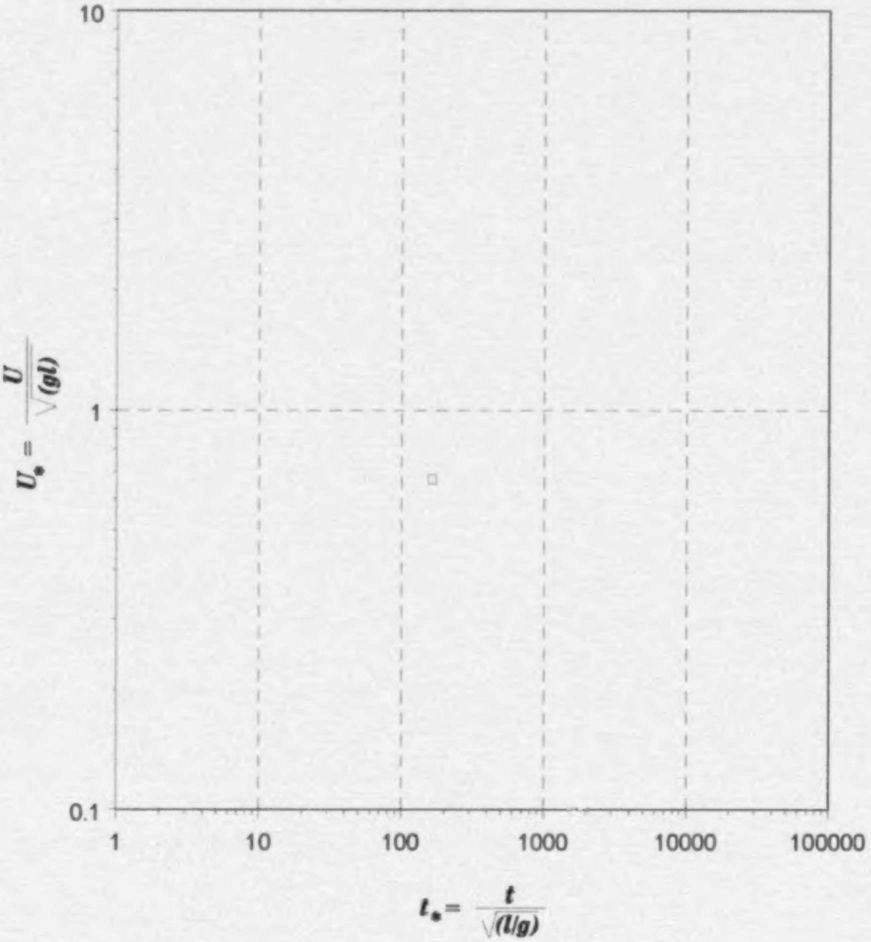


Figure C-033. Processed endurance data for Etheostoma grahami *(Rio Grande Darter): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner. (2009).*

Table C-033. Data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	24.1	0	24.1	24.1	0	1
U (m/s)	0.4	0	0.4	0.4	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

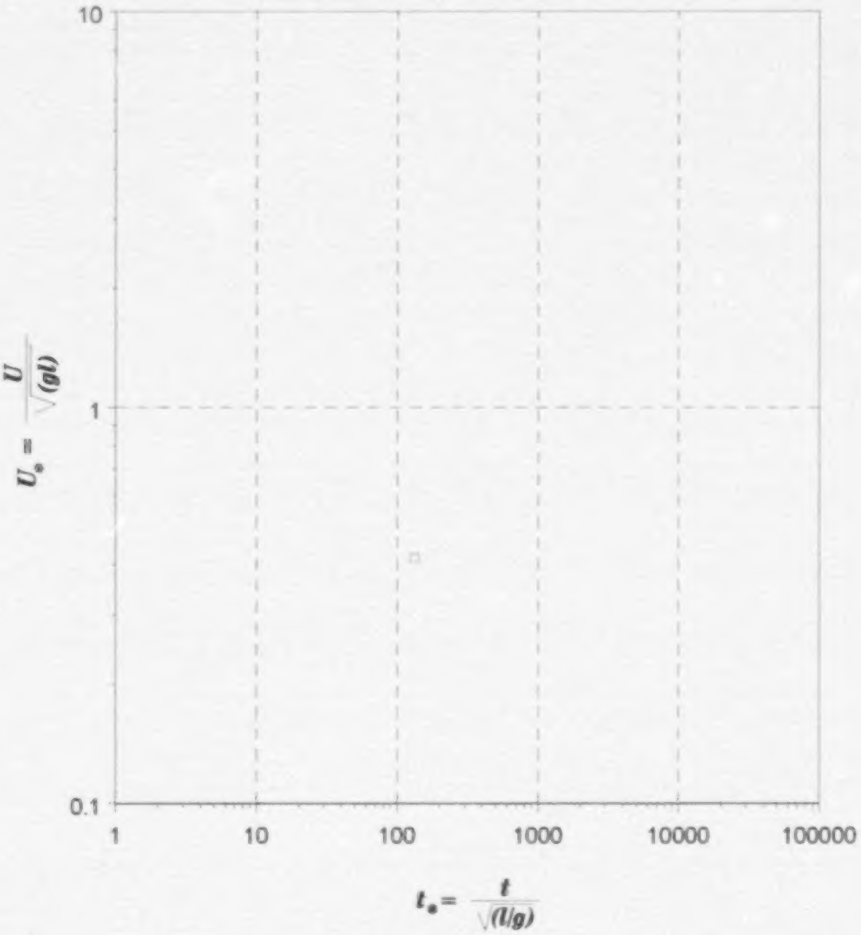


Figure C-034. Processed endurance data for Fundulus notatus *(Blackstripe Topminnow): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-034. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.056	0	0.056	0.056	0	1
T (C)	28.3	0	28.3	28.3	0	1
U (m/s)	0.307	0	0.307	0.307	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

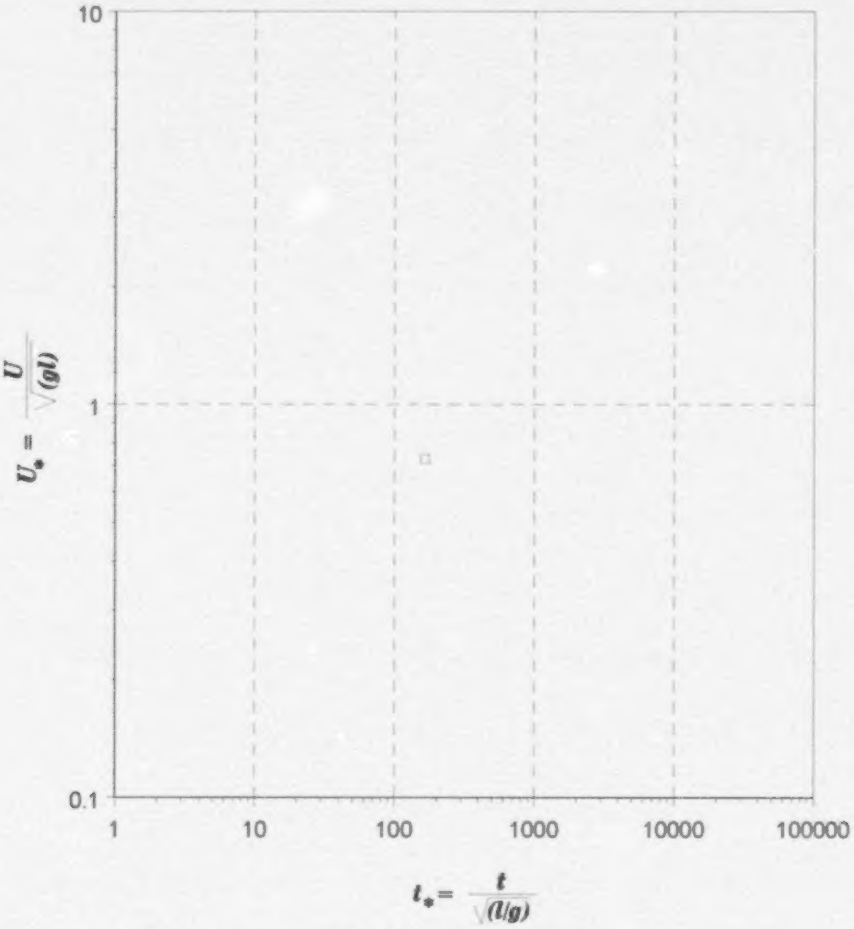


Figure C-035. Processed endurance data for Fundulus zebrinus *(Plains Killifish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-035. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	23.6	0	23.6	23.6	0	1
U (m/s)	0.434	0	0.434	0.434	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

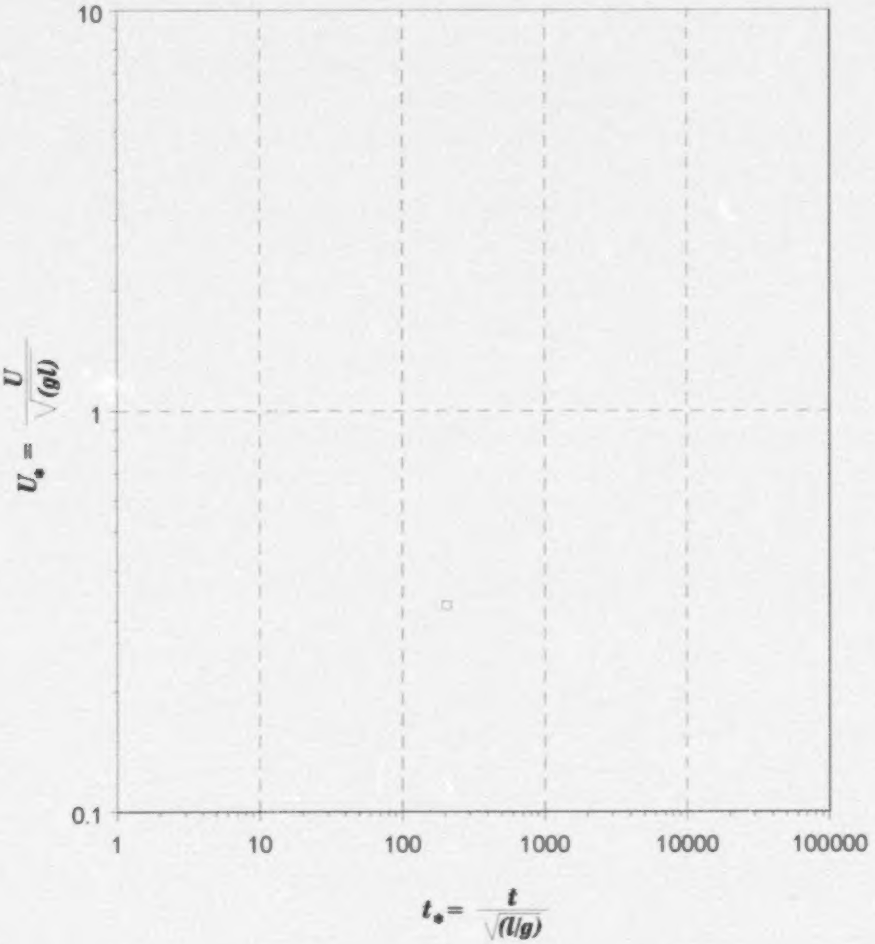
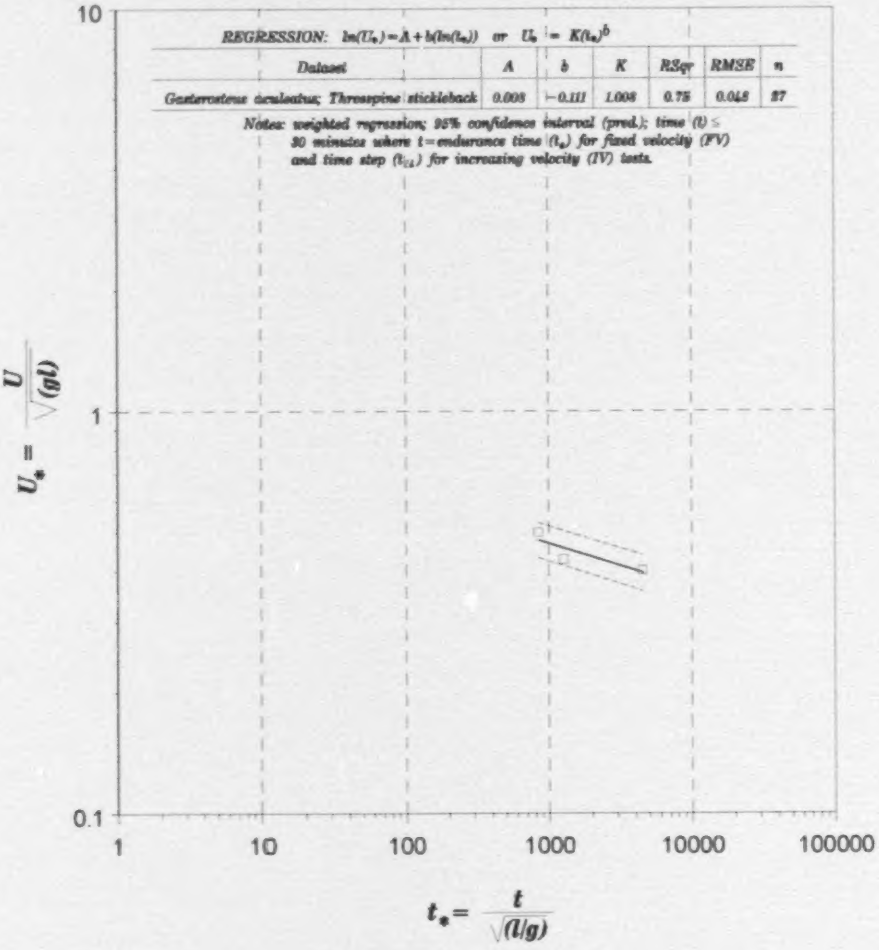


Figure C-036. Processed endurance data for Gambusia geiseri *(Largespring Gambusia): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner 2009).*

Table C-036. Data summary. Fish count 7, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.023	0	0.023	0.023	0	1
T (C)	22.7	0	22.7	22.7	0	1
U (m/s)	0.157	0	0.157	0.157	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Gasterosteus aculeatus; Threespine stickleback	0.008	-0.111	1.008	0.75	0.048	27

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure C-037. Processed endurance data for Gasterosteus aculeatus *(Threespine Stickleback): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Whoriskey and Wootton (1987).*

Table C-037. Data summary. Fish count 27, record count 3.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.048	0.003	0.044	0.05	0.006	2
T (C)	20	0	20	20	0	1
U (m/s)	0.305	0.036	0.264	0.35	0.086	3
t_e (s)	150	109	60	300	240	3
$t_{\Delta t}$ (s)	.	.	.	.	.	0

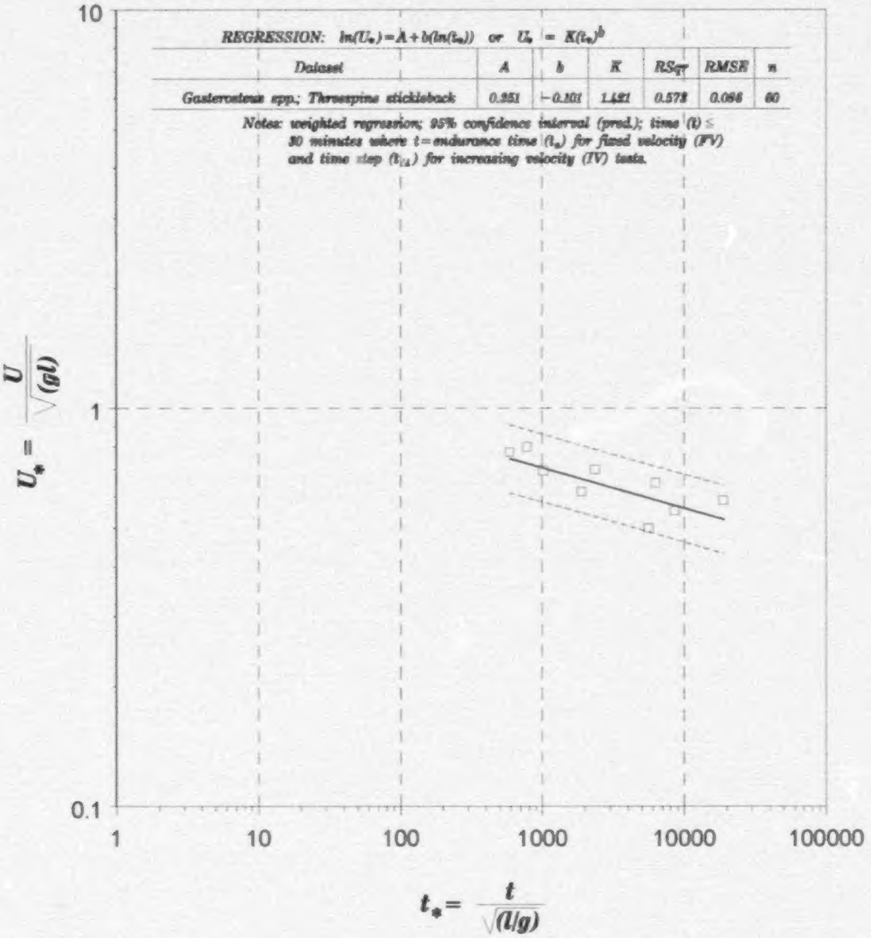


Figure C-038. Processed endurance data for Gasterosteus aculeatus *(Paxton Lake Threespine Stickleback): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Blake et al. (2005).*

Table C-038. Data summary. Fish count 60, record count 9.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0.005	0.044	0.055	0.011	2
T (C)	15	0	15	15	0	1
U (m/s)	0.447	0.062	0.368	0.571	0.206	9
t_e (s)	381	361	44	1261	1217	9
$t_{\Delta t}$ (s)	.	.	.	.	.	0

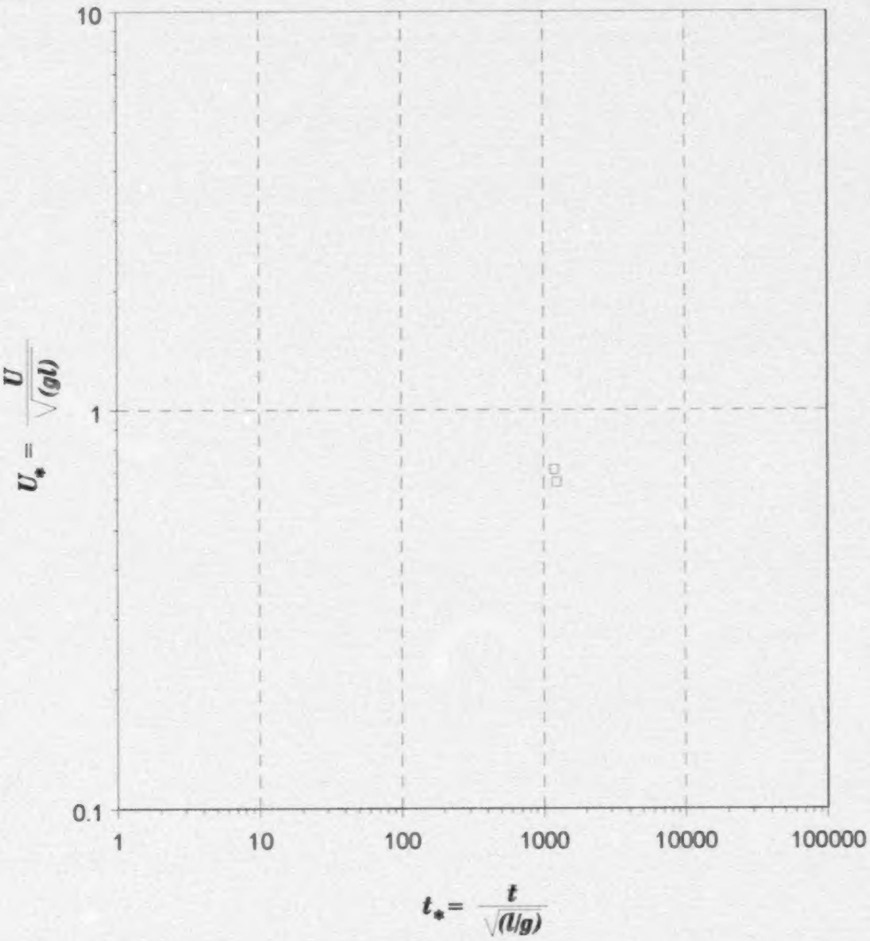


Figure C-039. Processed endurance data for Gila cypha *(Humpback Chub): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Berry and Pimentel (1985).*

Table C-039. Data summary. Fish count 156, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.096	0.003	0.093	0.099	0.006	2
T (C)	23.2	3	20	26	6	2
U (m/s)	0.668	0.035	0.63	0.7	0.07	2
t_e (s)	120	0	120	120	0	1
$t_{\Delta t}$ (s)	.	.	.	.	.	0

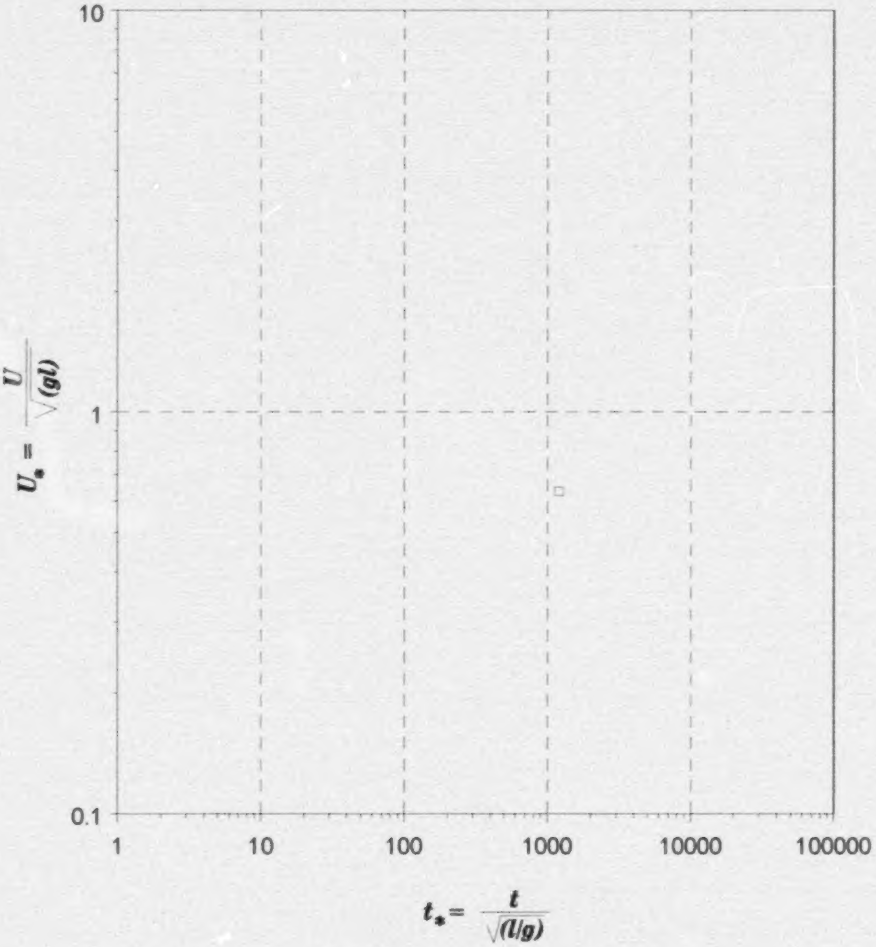


Figure C-040. Processed endurance data for Gila elegans *(Bonytail Chub):dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Berry and Pimentel (1985).*

Table C-040. Data summary. Fish count 59, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.097	0	0.097	0.097	0	1
T (C)	20	0	20	20	0	1
U (m/s)	0.62	0	0.62	0.62	0	1
t_e (s)	120	0	120	120	0	1
$t_{\Delta t}$ (s)	.	.	.	.	.	0

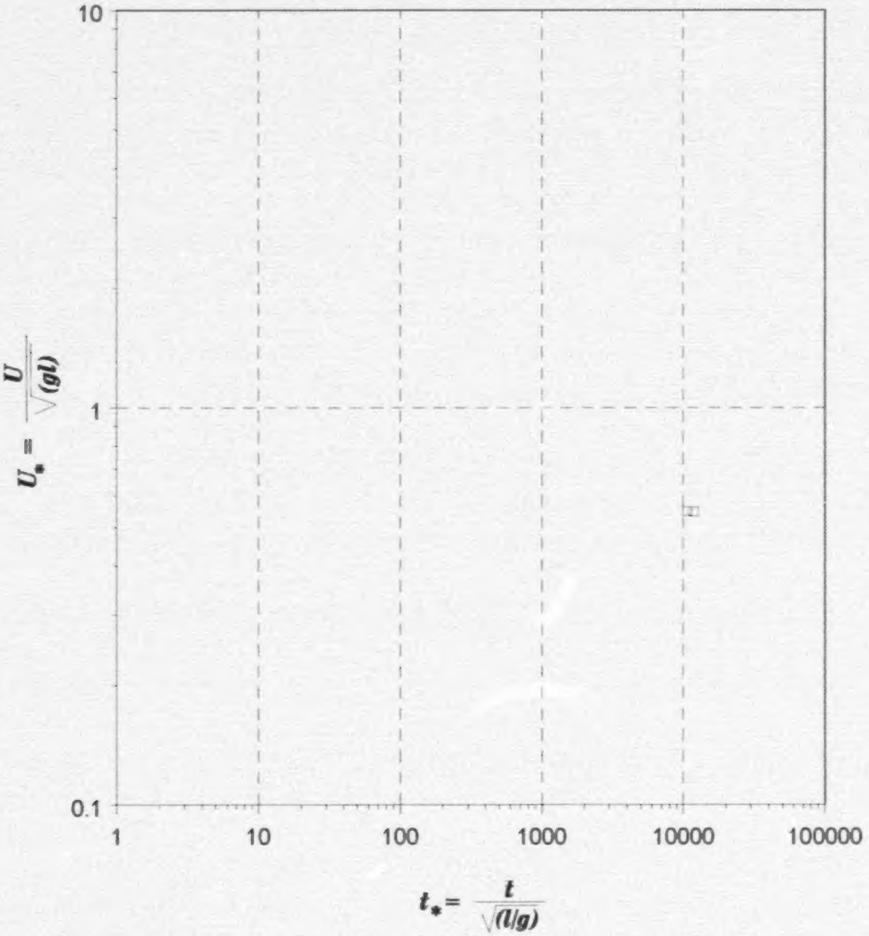


Figure C-041. Processed endurance data for Gobio gobio *(Gudgeon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Tudorache et al. (2008).*

Table C-041. Data summary. Fish count 16, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.112	0.012	0.1	0.123	0.023	2
T (C)	15	0	15	15	0	1
U (m/s)	0.572	0.031	0.542	0.602	0.06	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

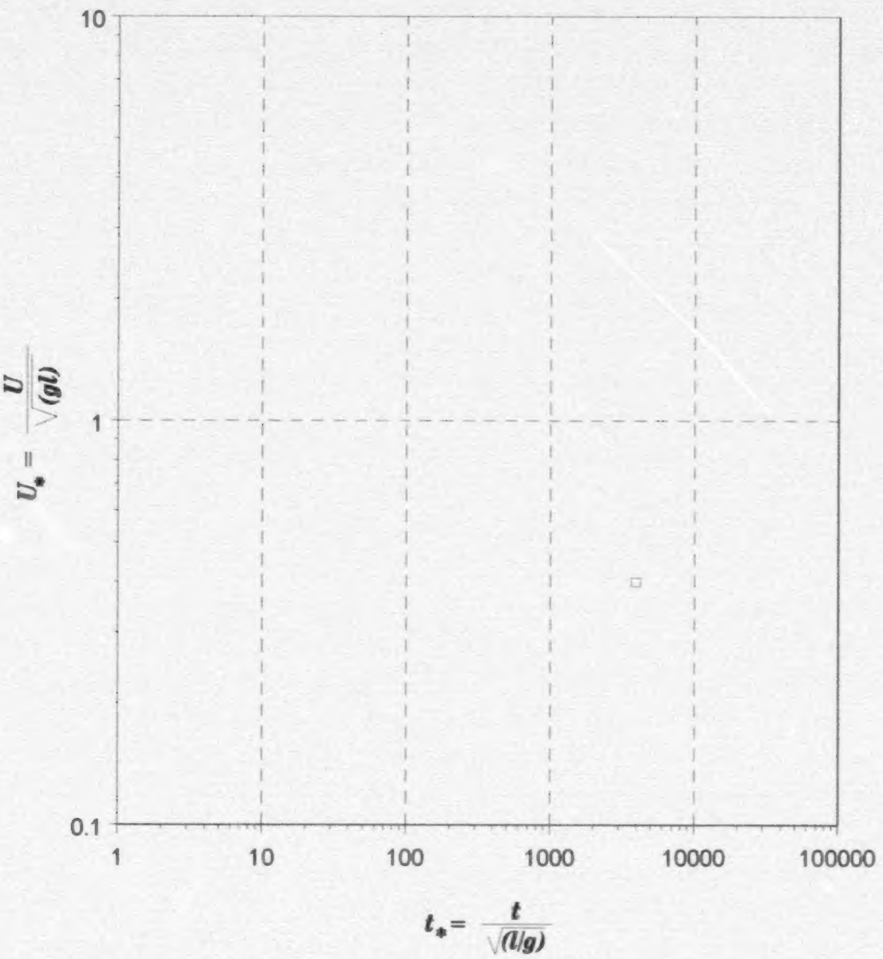


Figure C-042. Processed endurance data for Hiodon alosoides *(Goldeye): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Jones et al. (1973).*

Table C-042. Data summary. Fish count 2, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.23	0	0.23	0.23	0	1
T (C)	16	0	16	16	0	1
U (m/s)	0.6	0	0.6	0.6	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

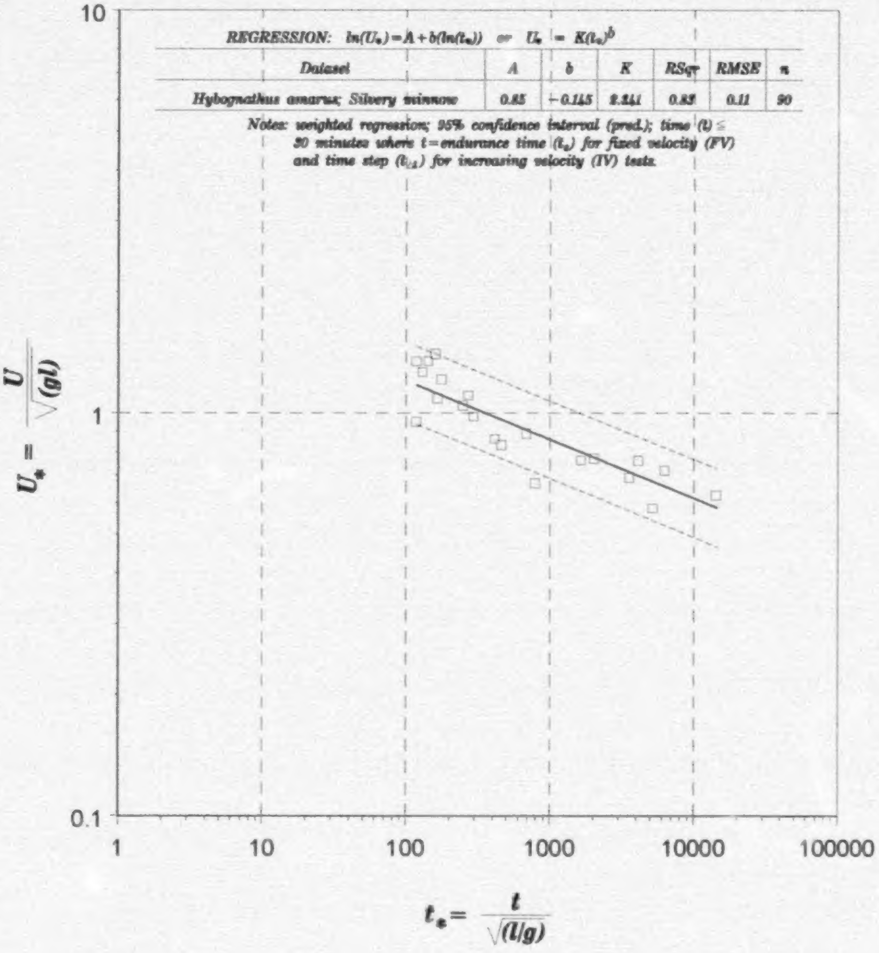


Figure C-043. Processed endurance data for Hybognathus amarus *(Silvery Minnow): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Bestgen et al. (2003).*

Table C-043. Data summary. Fish count 90, record count 21.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.071	0.001	0.069	0.071	0.002	2
T (C)	18.9	3.1	15	23	8	3
U (m/s)	0.728	0.204	0.484	1.168	0.684	21
t_e (s)	154	176	10	532	522	19
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

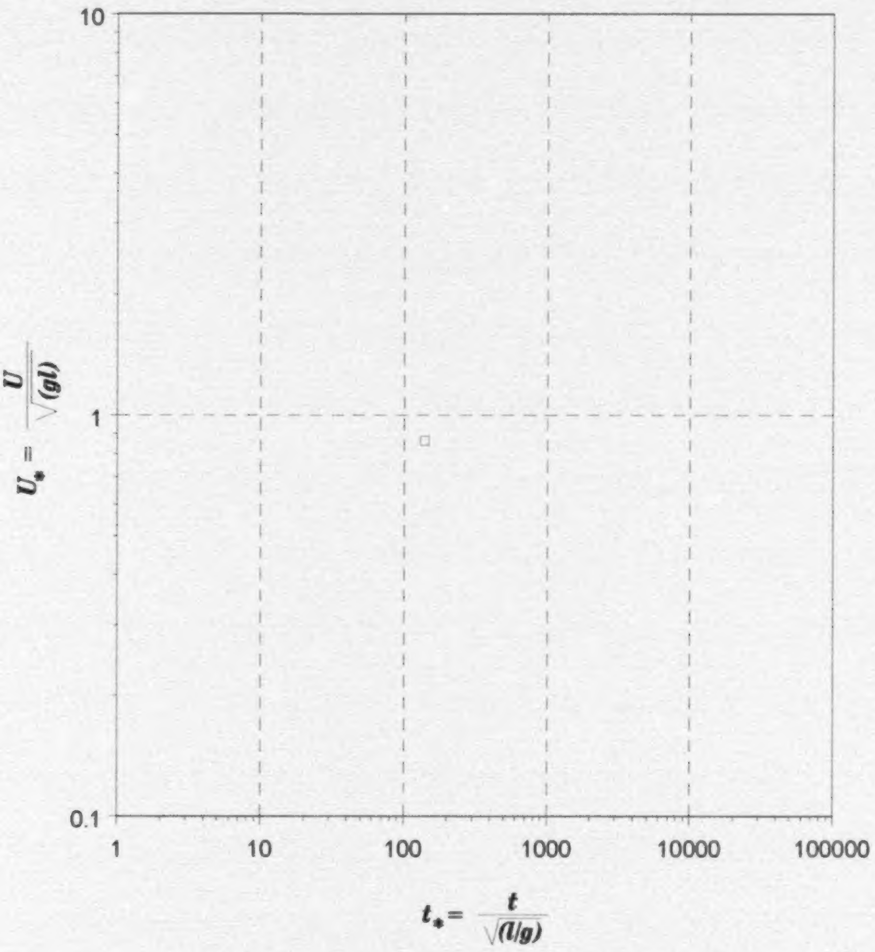


Figure C-044. Processed endurance data for Hybognathus placitus *(Plains Minnow): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-044. Data summary. Fish count 32, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0	0.51	0.51	0	1
T (C)	28.7	0	28.7	28.7	0	1
U (m/s)	0.611	0	0.611	0.611	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

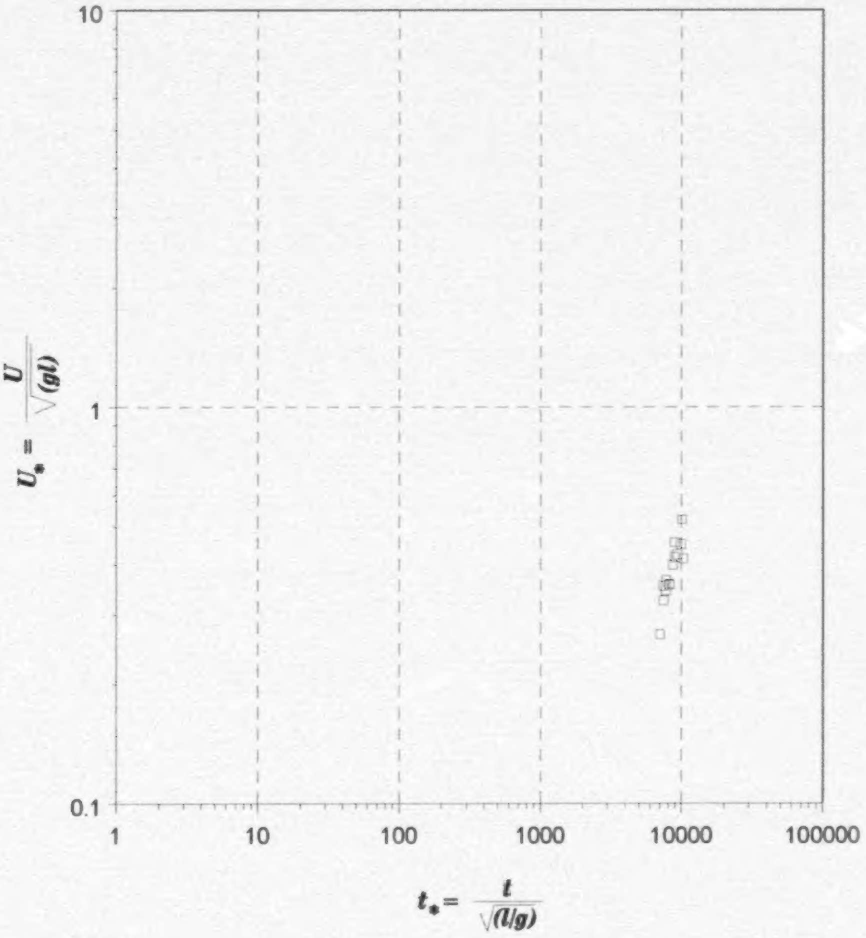
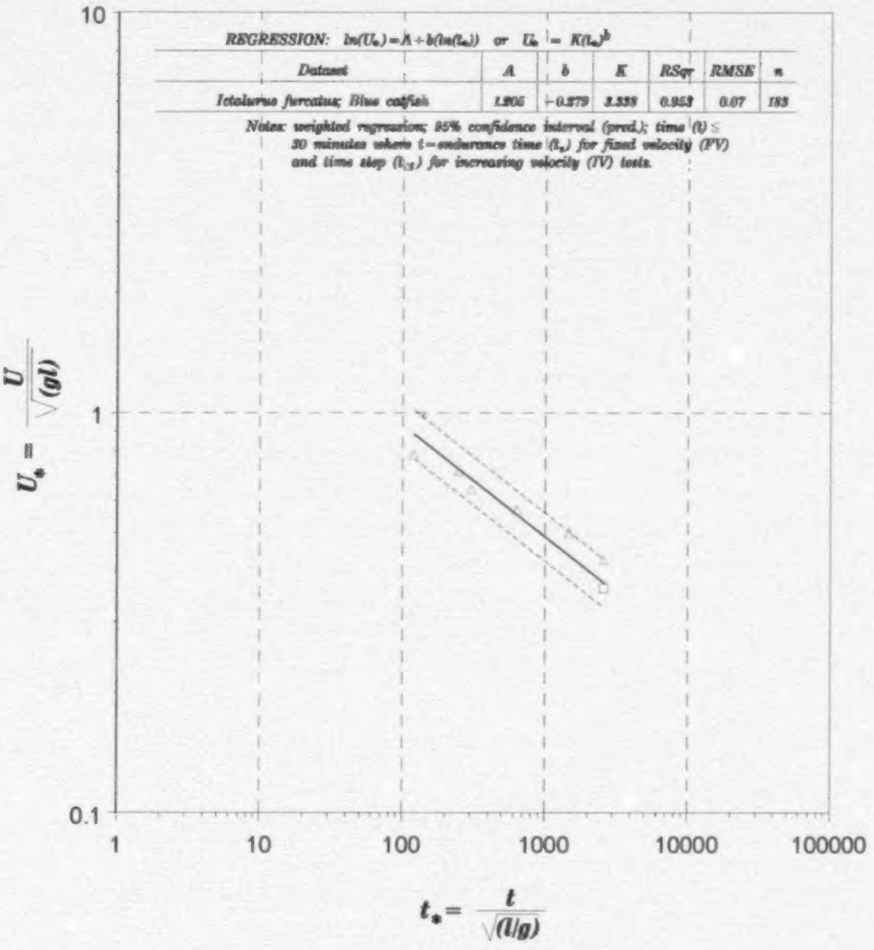


Figure C-045. Processed endurance data for Hypomesus transpacificus *(Delta Smelt): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Swanson and Cech (1995).*

Table C-045. Data summary. Fish count 71, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.055	0.01	0.033	0.071	0.038	14
T (C)	16	3	12	21	9	3
U (m/s)	0.266	0.017	.0223	0.305	0.082	13
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Ictalurus furcatus; Blue catfish	1.206	-0.279	3.338	0.953	0.07	183

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure C-046. Processed endurance data for for Ictalurus furcatus *(Blue Catfish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Beecham et al. (2007); red triangles are data from Beecham et al. (2009); green star is data from Leavy and Bonner (2009).*

Table C-046. Data summary. Fish count 183, record count 8.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.234	0.058	0.052	0.277	0.225	3
T (C)	20.7	2.2	20	29.6	9.6	3
U (m/s)	0.706	0.159	0.6	1.1	0.5	6
t_e (s)	300	173	17	432	415	7
$t_{\Delta t}$ (s)	10	0	10	10	0	1

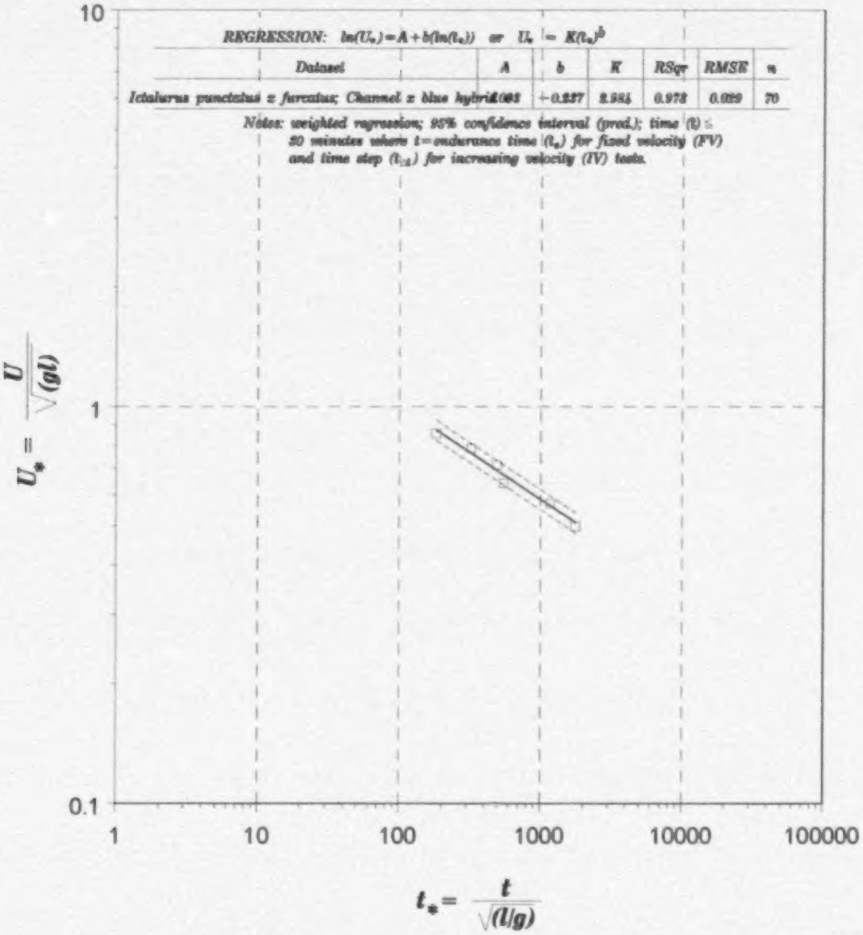


Figure C-047. Processed endurance data for Ictalurus punctatus *x furcatus (channel x blue hybrid): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Beecham et al. (2009).*

Table C-047. Data summary. Fish count 70, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.2	0	0.2	0.2	0	1
T (C)	20.5	0	20.5	20.5	0	1
U (m/s)	0.974	0.18	0.7	1.2	0.5	6
t_e (s)	99	80	26	252	226	6
$t_{\Delta t}$ (s)	.	.	.	.	.	0

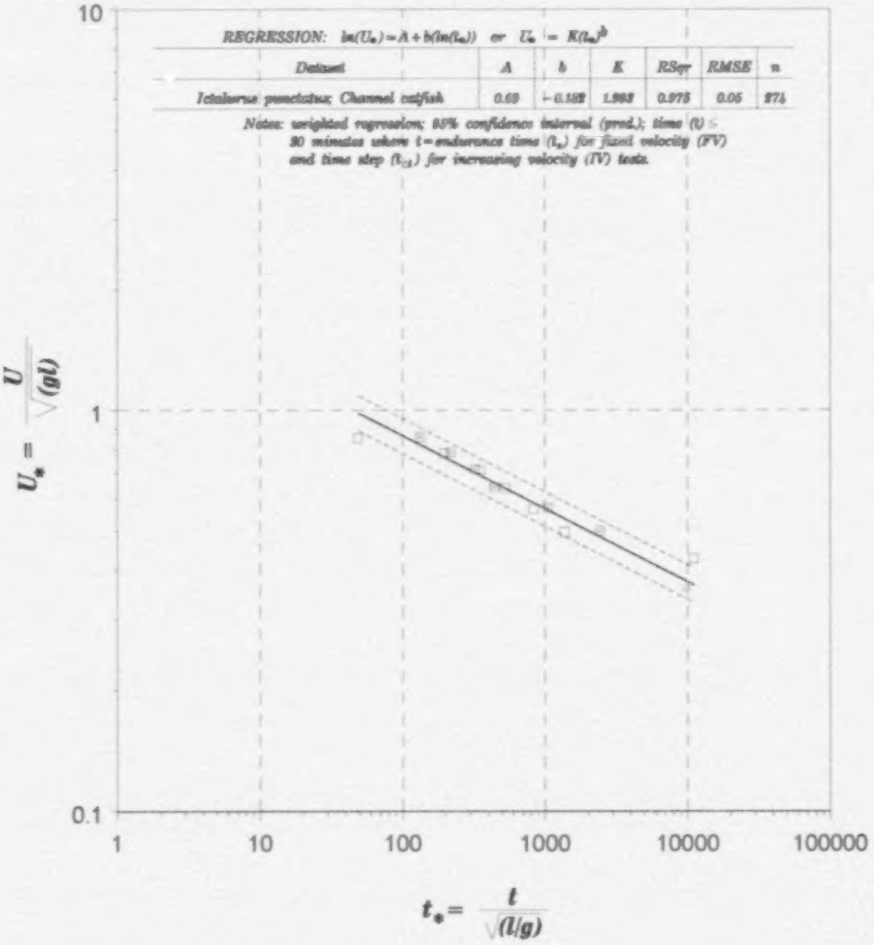


Figure C-048. Processed endurance data for Ictalurus punctatus *(Channel Catfish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Beecham et al. (2007); red triangles are data from Beecham et al. (2007); green stars are data from Beecham et al. (2009).*

Table C-048. Data summary. Fish count 274, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.228	0.036	0.2	0.276	0.076	3
T (C)	20.3	0.2	20	20.5	0.5	2
U (m/s)	0.801	0.211	0.6	1.2	0.6	7
t_e (s)	725	762	7	1656	1649	14
$t_{\Delta t}$ (s)	.	.	.	.	.	0

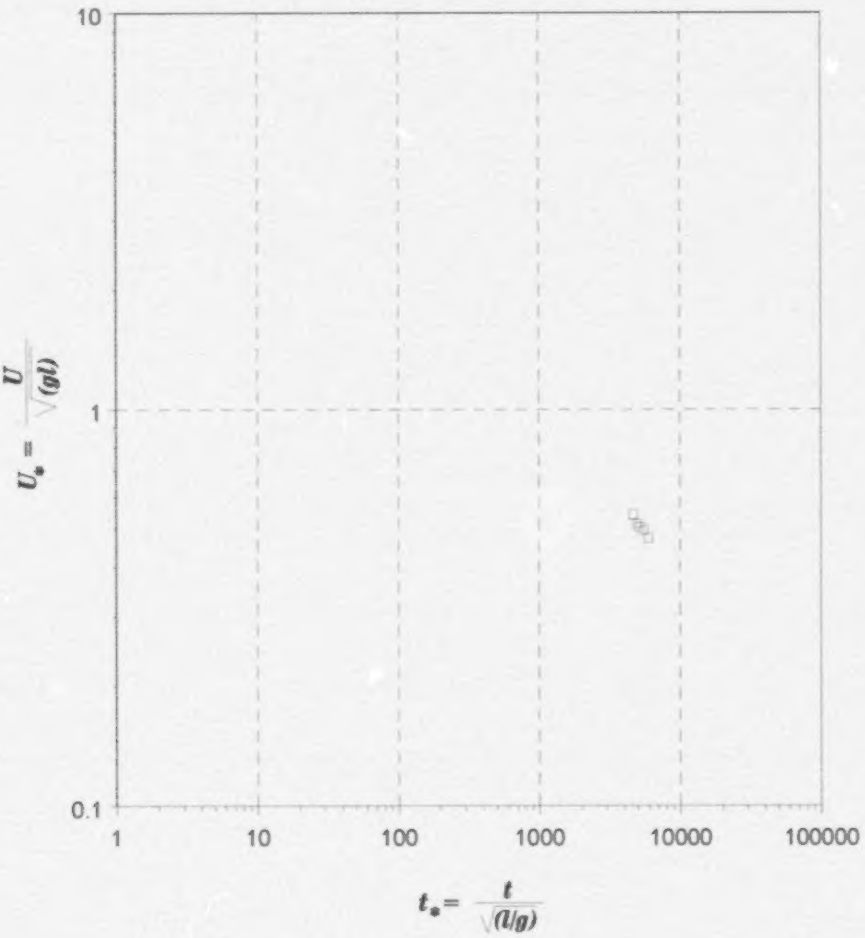


Figure C-049. Processed endurance data for Iotichthys phlegethontis *(Least Chub): dimensionless swim speed (U^*) versus dimensionless time-to-fatigue (t^*). Blue squares are data from Aedo et al. (2009).*

Table C-049. Data summary. Fish count 40, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.033	0.004	0.025	0.041	0.016	5
T (C)	17	0	17	17	0	1
U (m/s)	0.285	0.028	0.234	0.344	0.11	5
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

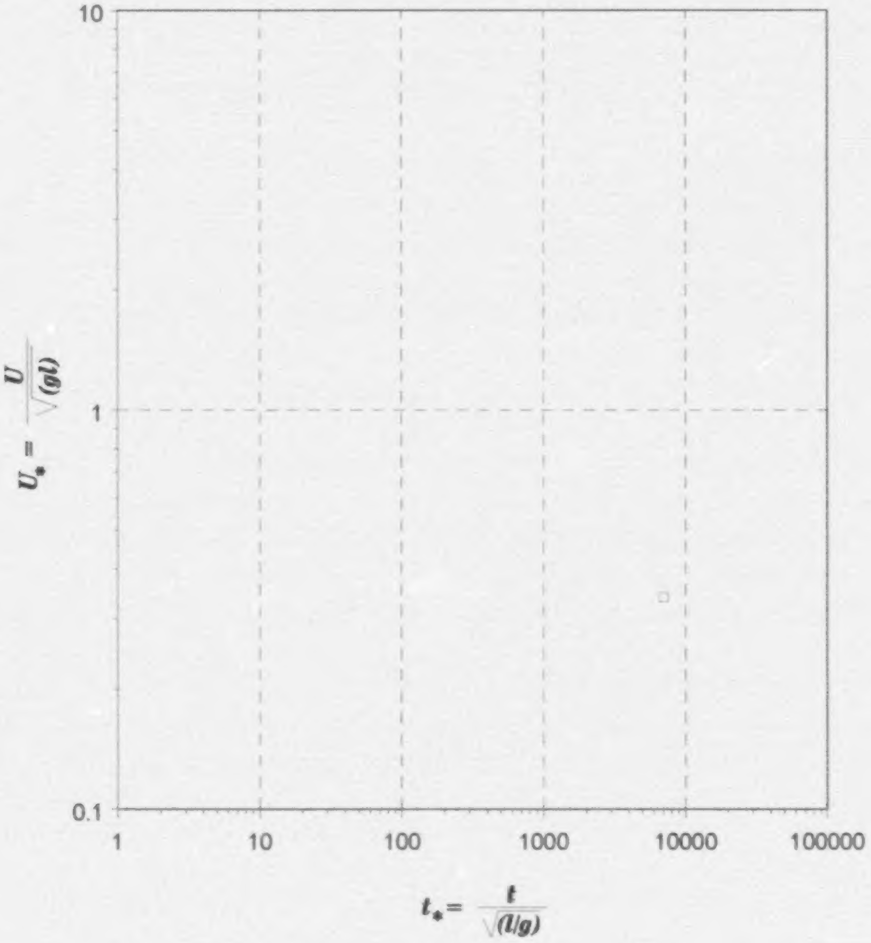


Figure C-050. Processed endurance data for Lampetra tridentata *(Pacific Lamprey): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Mesa et al. (2003a).*

Table C-050. Data summary. Fish count 24, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.641	0	0.641	0.641	0	1
T (C)	15	0	15	15	0	1
U (m/s)	0.851	0	0.851	0.851	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

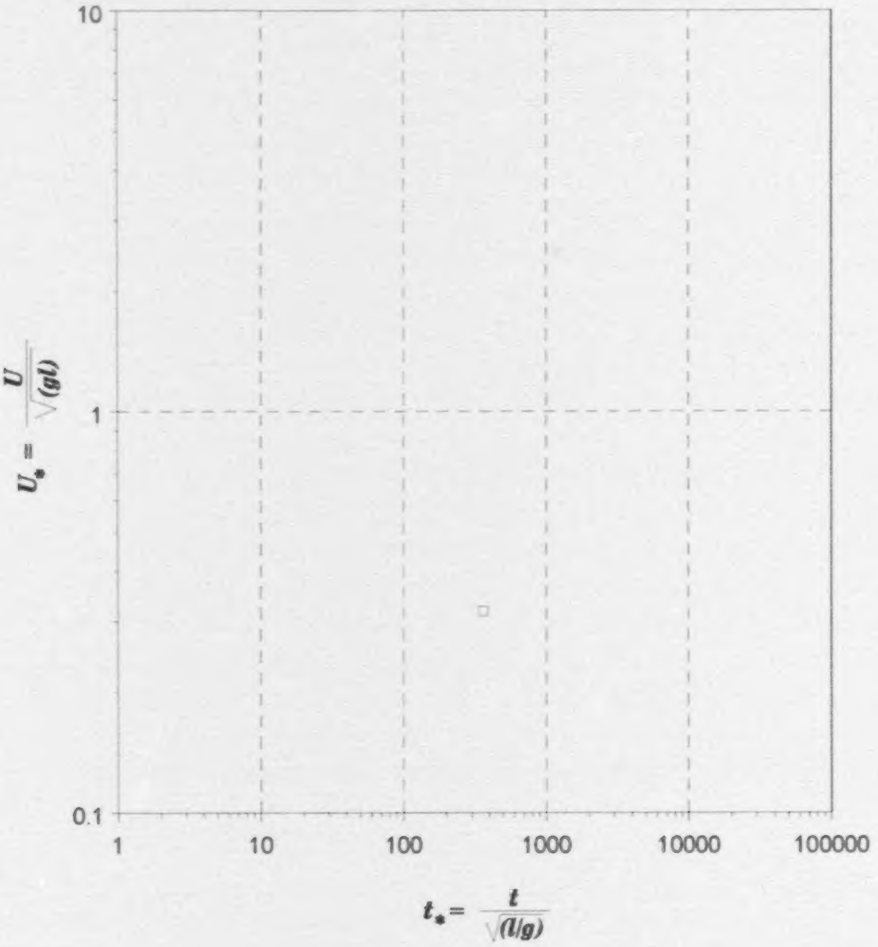


Figure C-051. Processed endurance data for Lepidomeda aliciae *(Southern Leatherside Chub): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Aedo et al. (2009).*

Table C-051. Data summary. Fish count 21, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.078	0.019	0.04	0.104	0.064	68
T (C)	17	0	17	17	0	1
U (m/s)	0.542	0.112	0.373	0.717	0.344	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

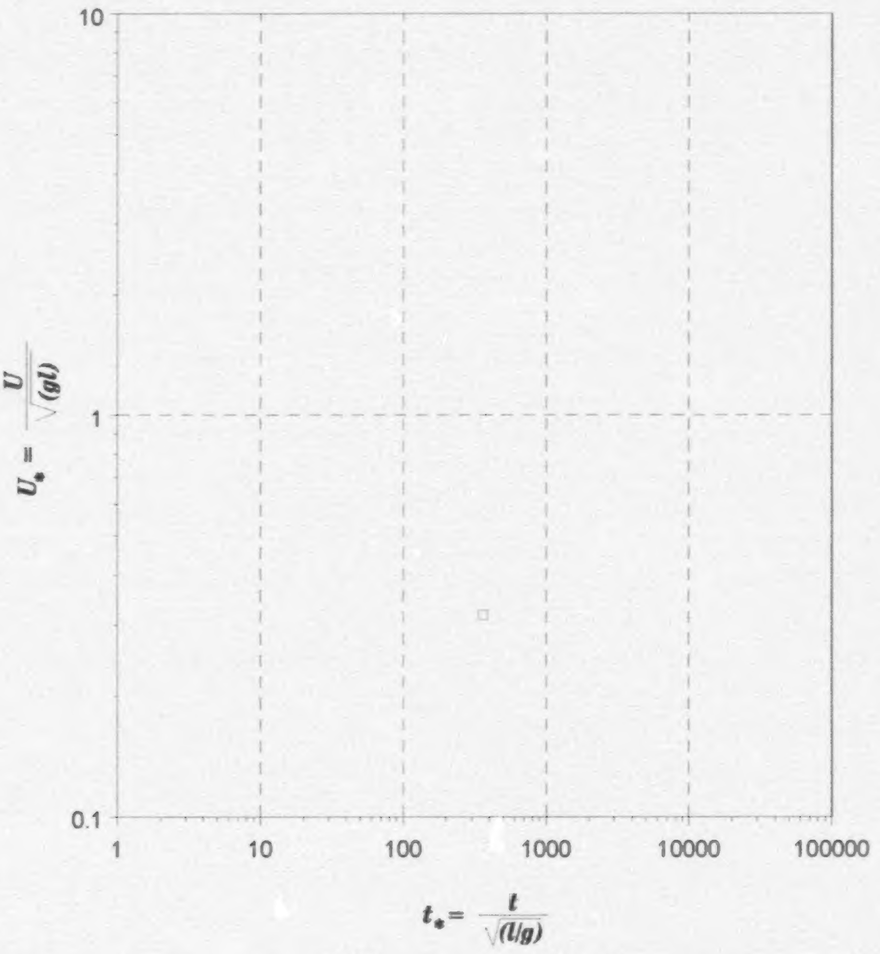


Figure C-052. Processed endurance data for Lepisosteus osseus *(Longnose Gar): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Webb et al. (1992).*

Table C-052. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.266	0	0.266	0.266	0	1
T (C)	25	0	25	25	0	1
U (m/s)	0.514	0	0.514	0.514	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	60	0	60	60	0	1

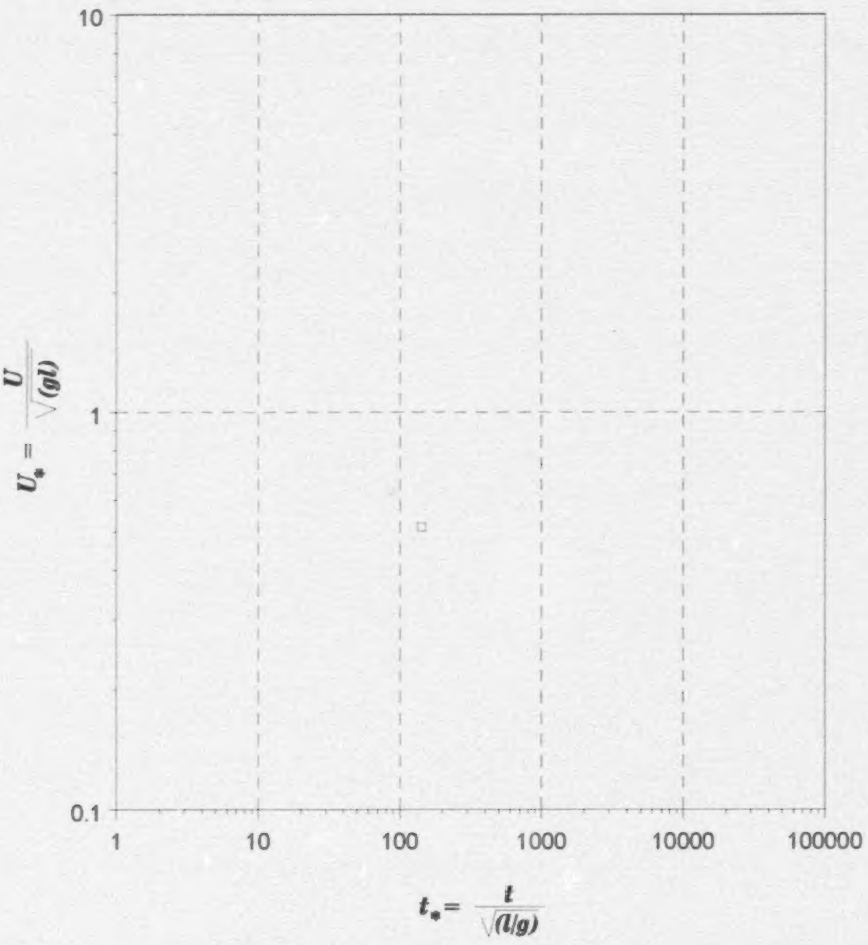


Figure C-053. Processed endurance data for Lepomis auritus *(Redbreast Sunfish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Leavy and Bonner (2009).*

Table C-053. Data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.048	0	0.048	0.048	0	1
T (C)	26.7	0	26.7	26.7	0	1
U (m/s)	0.354	0	0.354	0.354	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

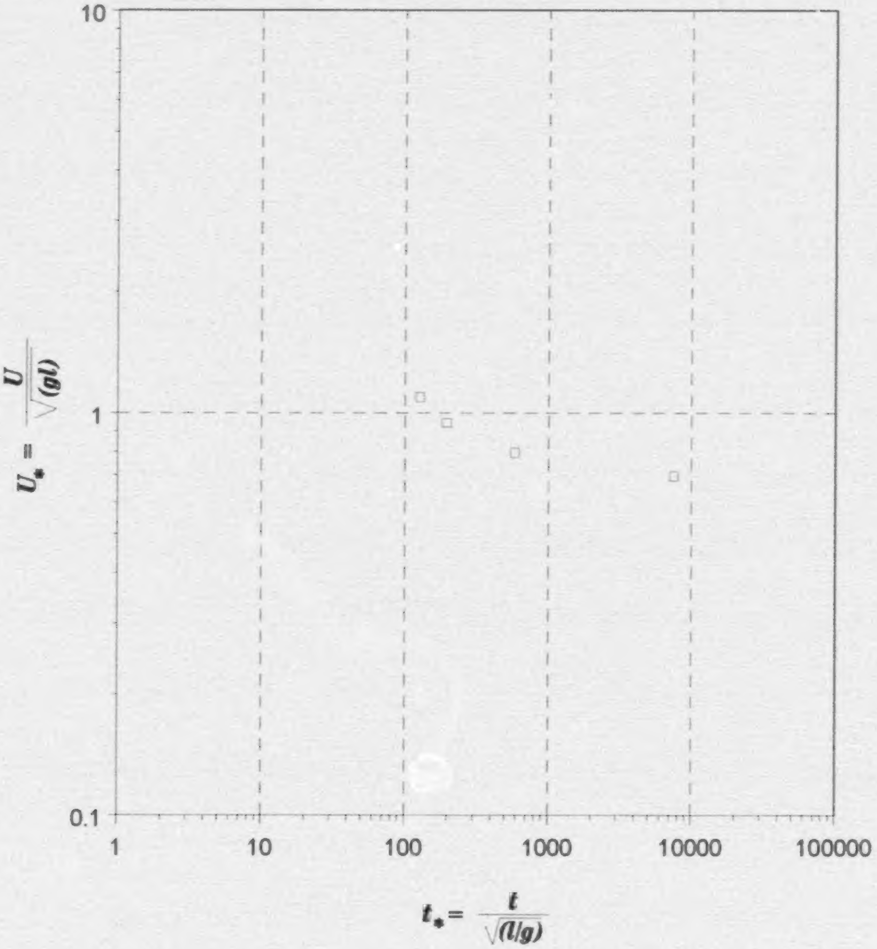


Figure C-054. Processed endurance data for Lepomis incisor *(Sunfish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Tsukamoto et al. (1975).*

Table C-054. Data summary. Fish count 20, record count 4.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.103	0	0.103	0.103	0	1
T (C)	22	0	22	22	0	1
U (m/s)	0.888	0.155	0.7	1.1	0.4	4
t_e (s)	216	329	13	770	757	4
$t_{\Delta t}$ (s)	.	.	.	.	.	0

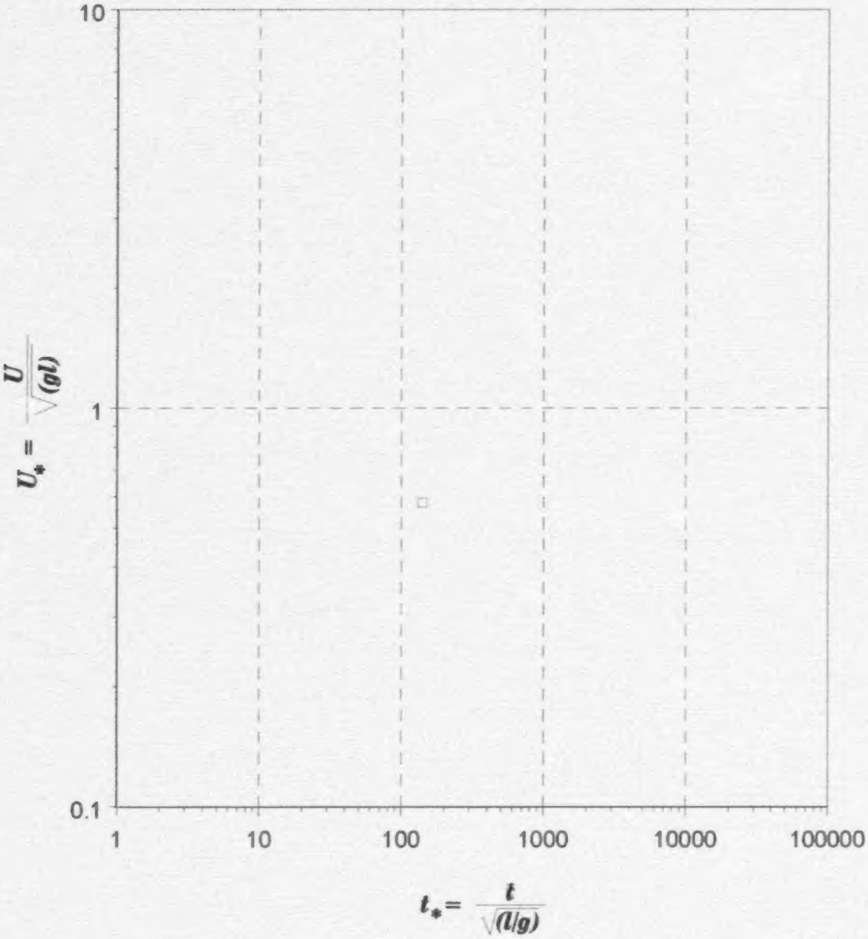


Figure C-055. Processed endurance data for Lepomis macrochirus *(Bluegill): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-055. Data summary. Fish count 4, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.05	0	0.05	0.05	0	1
T (C)	25.3	0	25.3	25.3	0	1
U (m/s)	0.405	0	0.405	0.405	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

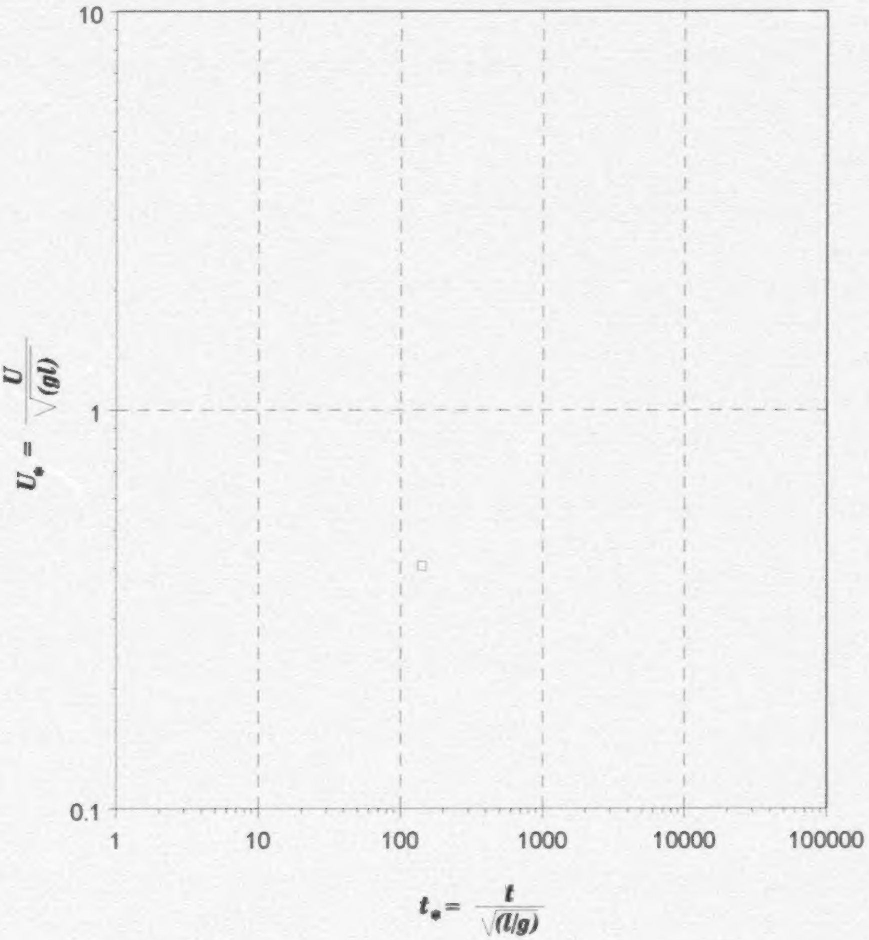
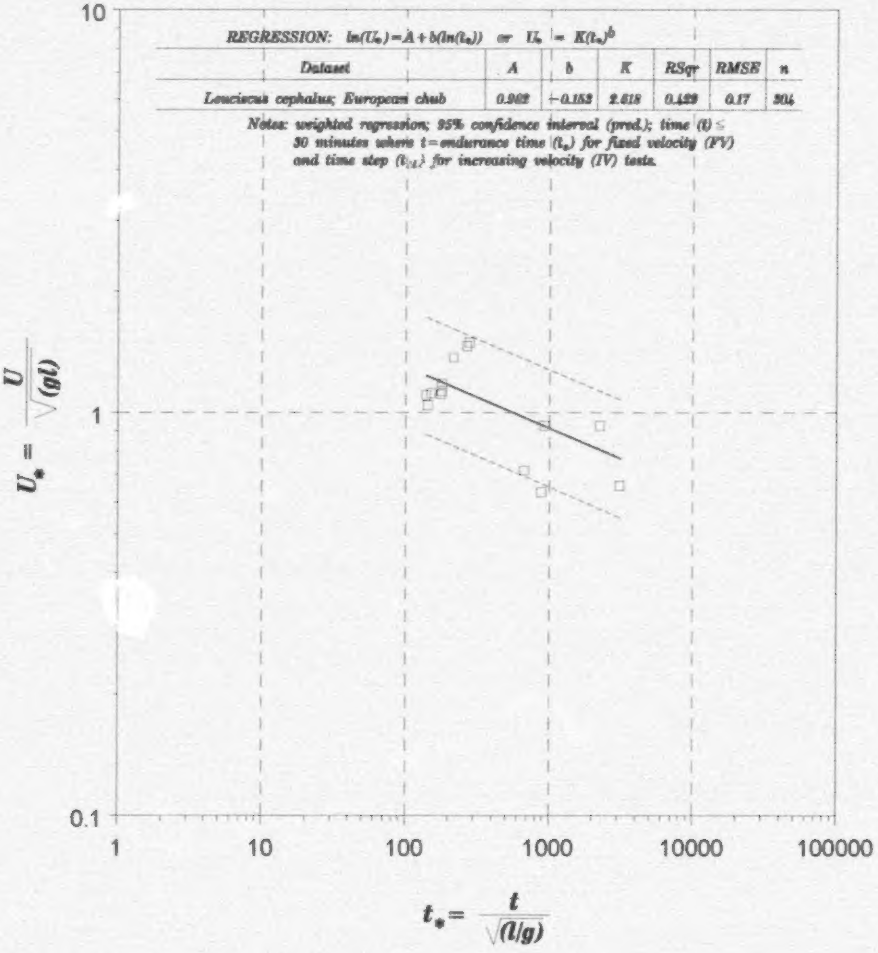


Figure C-056. Processed endurance data for Lepomis megalotis *(Longear Sunfish): dimensionless swim speed (U^*) versus dimensionless time-to-fatigue (t^*). Blue squares are data from Leavy and Bonner (2009).*

Table C-056. Data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.049	0	0.049	0.049	0	1
T (C)	24.4	0	24.4	24.4	0	1
U (m/s)	0.28	0	0.28	0.28	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Leuciscus cephalus; European chub	0.962	−0.153	2.618	0.429	0.17	304

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure C-057. Processed endurance data for Leuciscus cephalus *(European Chub): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Clough and Turnpenny (2000).*

Table C-057. Data summary. Fish count 304, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.12	0.055	0.05	0.202	0.152	13
T (C)	13.3	4.1	8.4	20	11.6	13
U (m/s)	1.156	0.286	0.65	1.556	0.906	12
t_e (s)	161	109	66	360	294	5
$t_{\Delta t}$ (s)	20	0	20	20	0	1

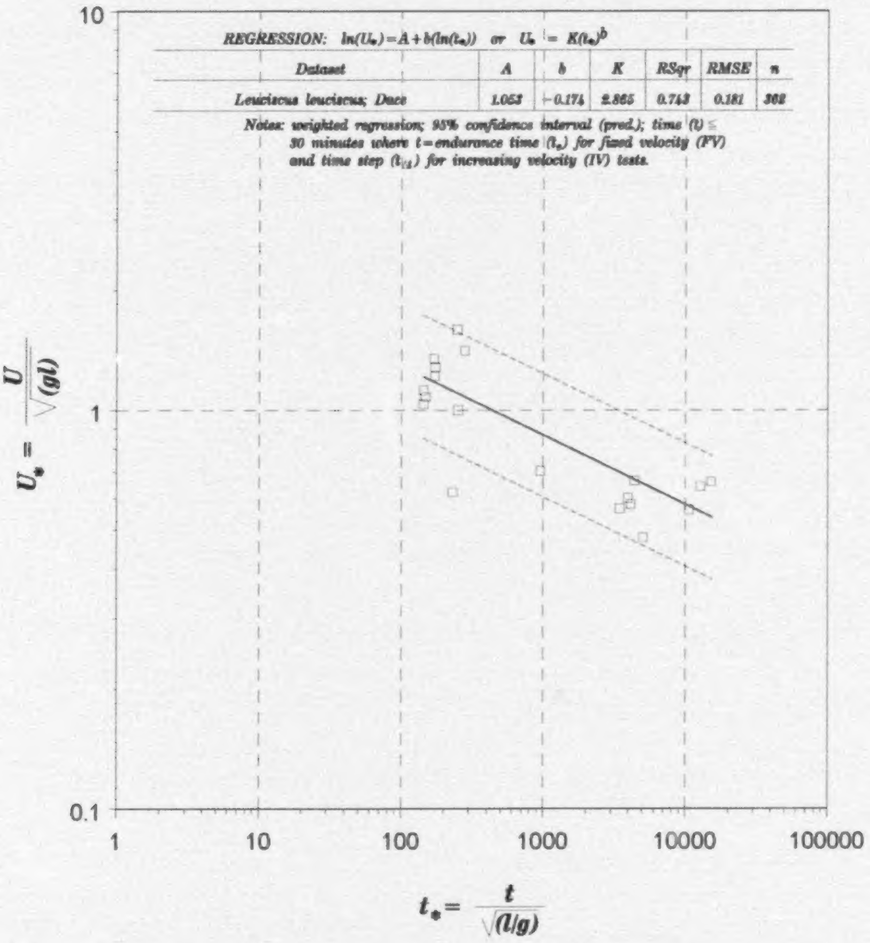


Figure C-058. Processed endurance data for Leuciscus leuciscus *(Dace): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Clough and Turnpenny (2000).*

Table C-058. Data summary. Fish count 362, record count 19.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.141	0.049	0.05	0.192	0.142	17
T (C)	14.6	5.1	4.1	20.9	16.8	17
U (m/s)	1.079	0.335	0.45	1.547	1.097	14
t_e (s)	920	619	32	1758	1726	10
$t_{\Delta t}$ (s)	20	0	20	20	0	1

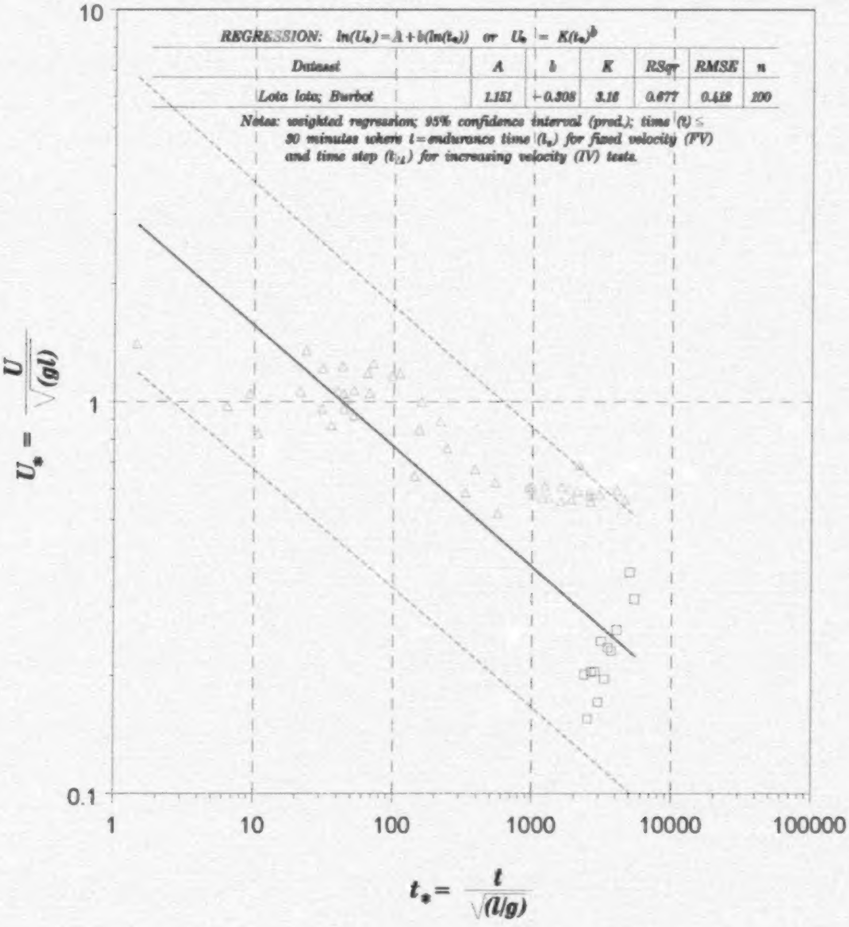


Figure C-059. Processed endurance data for Lota lota *(Burbot): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973); red triangles are data from Vokoun and Watrous (2009).*

Table C-059. Data summary. Fish count 100, record count 60.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.296	0.135	0.12	0.63	0.51	34
T (C)	13.8	4	10	18	8	2
U (m/s)	0.753	0.45	0.339	1.91	1.571	56
t_e (s)	117	156	0	635	635	47
$t_{\Delta t}$ (s)	600	0	600	600	0	1

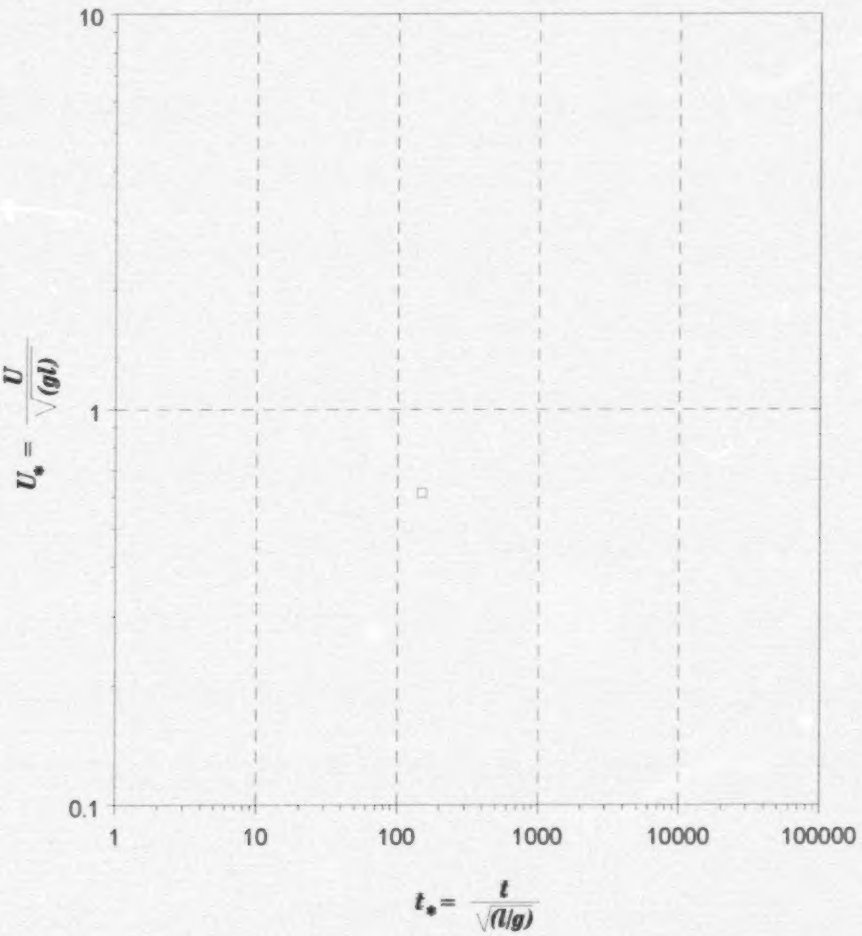


Figure C-060. Processed endurance data for Luxilus chrysocephalus *(Striped Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-060. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.044	0	0.044	0.044	0	1
T (C)	27.5	0	27.5	27.5	0	1
U (m/s)	0.403	0	0.403	0.403	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

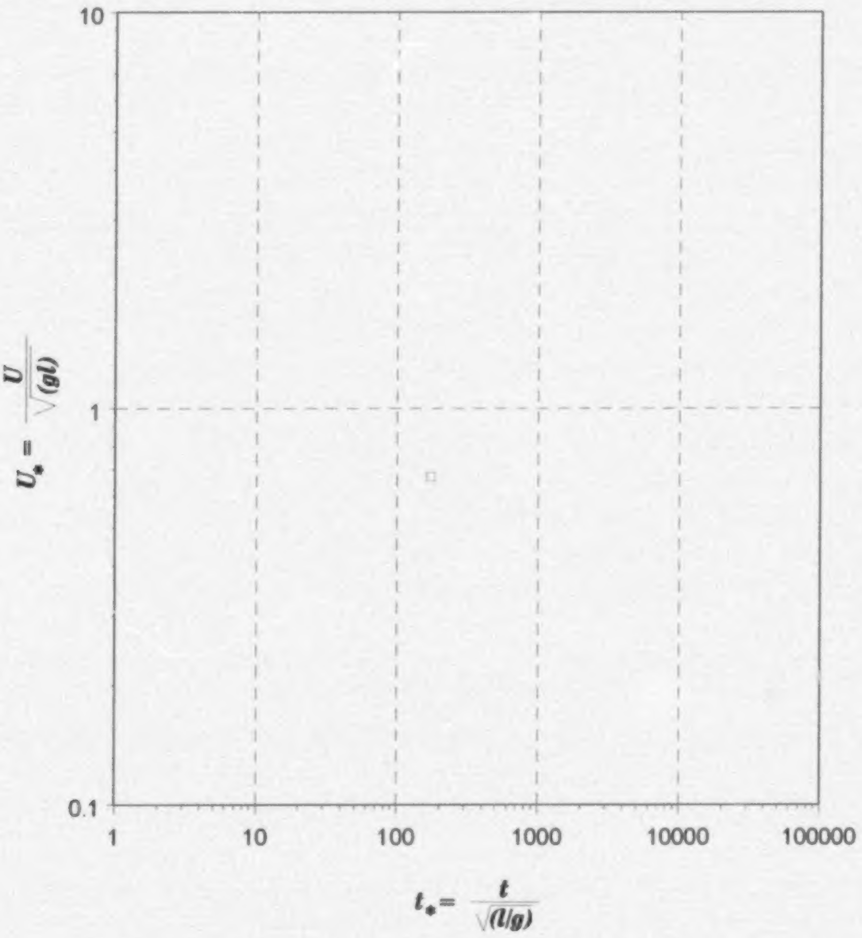


Figure C-061. Processed endurance data for Lythrurus fumeus *(Ribbon Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-061. Data summary. Fish count 11, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.033	0	0.033	0.033	0	1
T (C)	27.2	0	27.2	27.2	0	1
U (m/s)	0.381	0	0.381	0.381	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

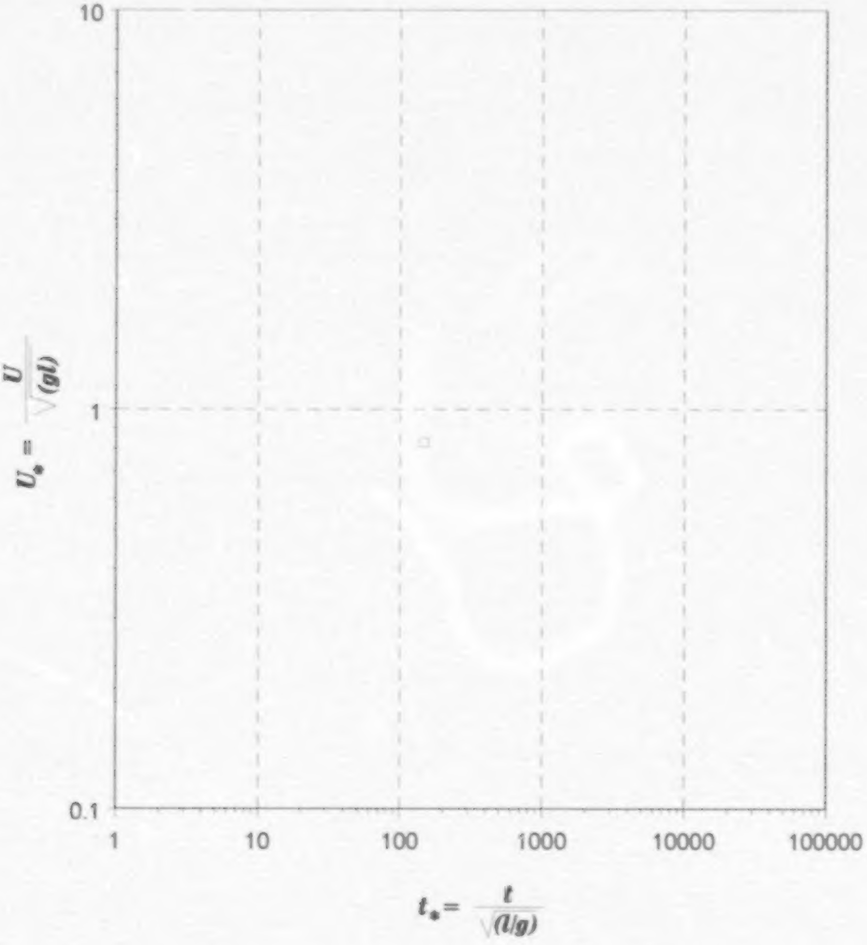


Figure C-062. Processed endurance data for Lythrurus umbratilis *(Redfin Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Leavy and Bonner (2009).*

Table C-062. Data summary. Fish count 13, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.045	0	0.045	0.045	0	1
T (C)	29	0	29	29	0	1
U (m/s)	0.55	0	0.55	0.55	0	1
t_e (s)	-	-	-	-	-	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

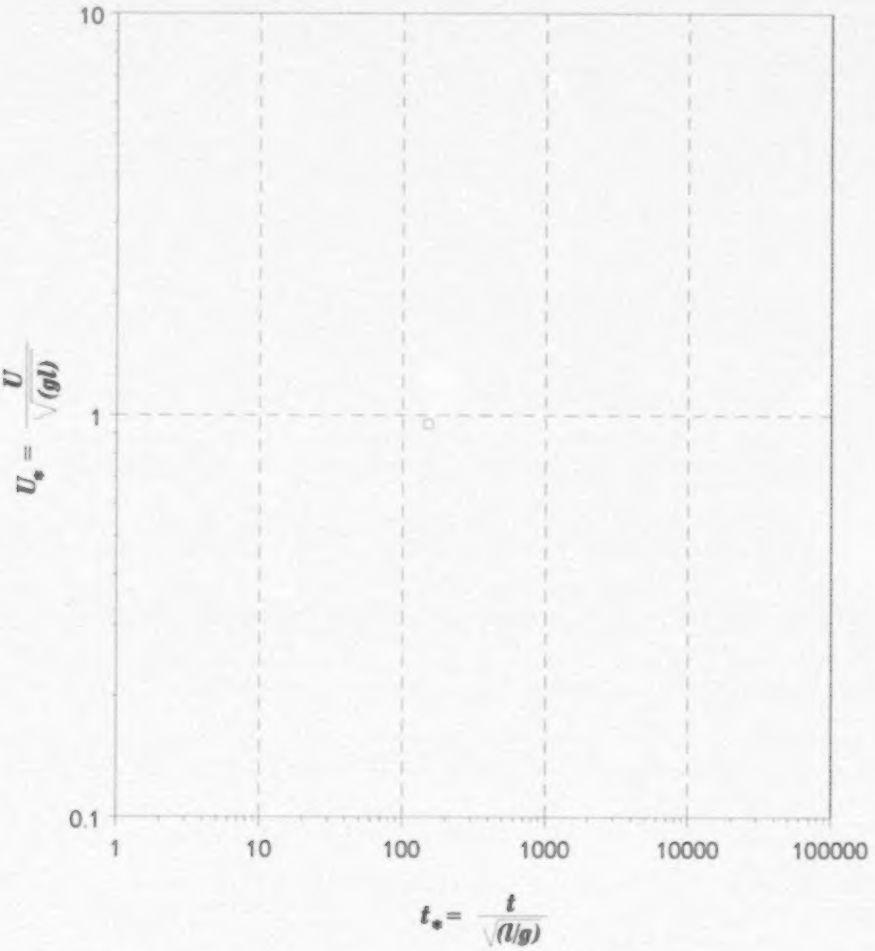


Figure C-063. Processed endurance data for Macrhybopsis aestivalis *(Speckled Chub): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-063. Data summary. Fish count 11, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	25.3	0	25.3	25.3	0	1
U (m/s)	0.619	0	0.619	0.619	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

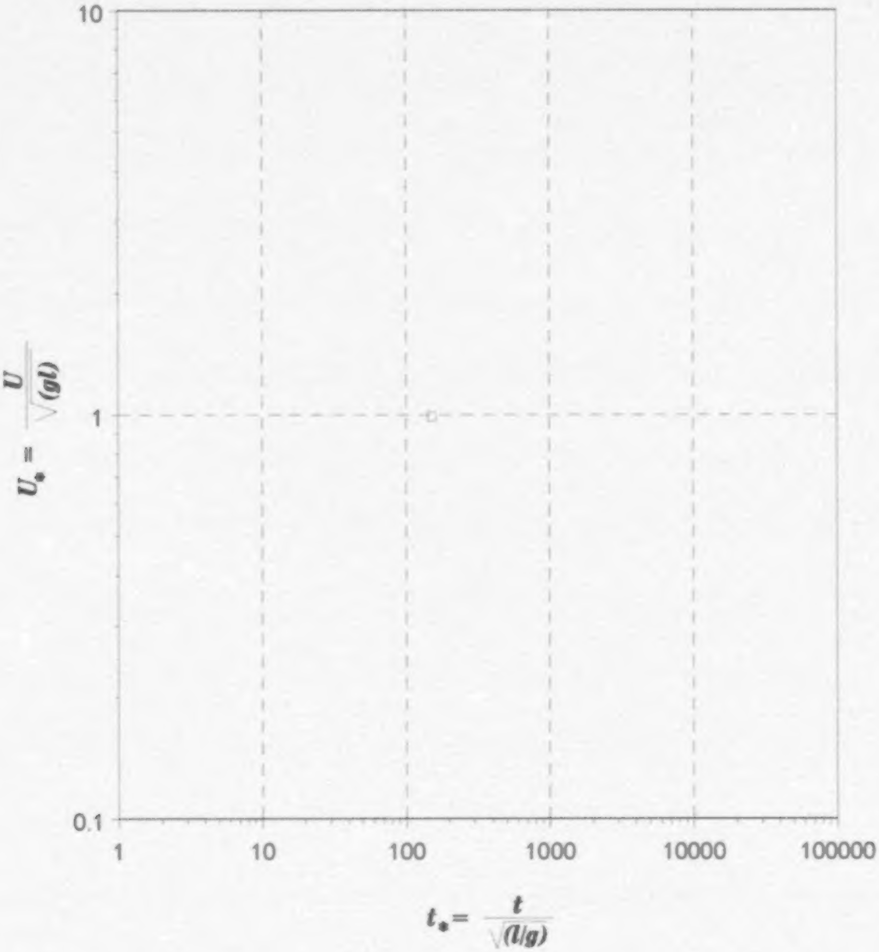


Figure C-064. Processed endurance data for Menidia beryllina *(Inland Silverside): dimensionless swim speed (U^*) versus dimensionless time-to-fatigue (t^*). Blue square is data from Swanson and Cech (1995); red triangles are data from Leavy and Bonner (2009).*

Table C-064. Data summary. Fish count 26, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.056	0.013	0.038	0.065	0.027	2
T (C)	22.1	7.1	17	31.7	14.7	2
U (m/s)	0.301	0.001	0.3	0.302	0.002	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	396	286	10	600	590	2

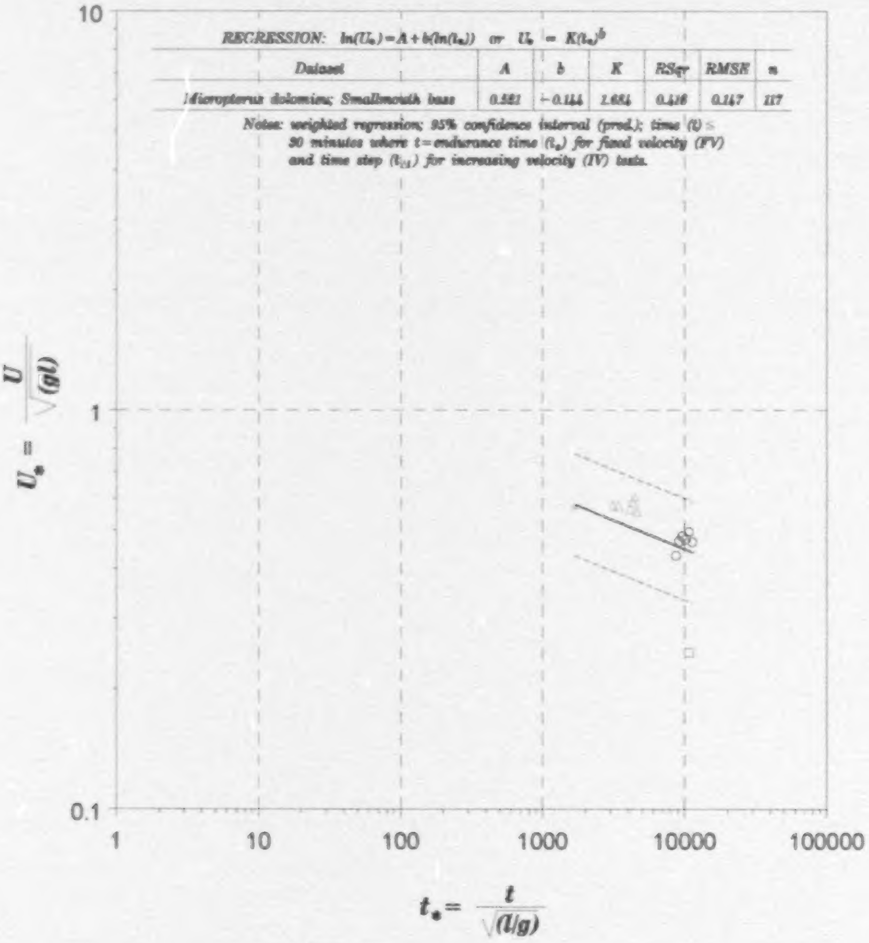


Figure C-065. Processed endurance data for Micropterus dolomieu *(Smallmouth Bass): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from McDonald et al. (1991); red triangles are data from Bunt et al. (1999); green stars are data from Cooke and Bunt (2001); black circles are data from Peake (2004a).*

Table C-065. Data summary. Fish count 117, record count 14.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0.064	0.123	0.424	0.307	14
T (C)	18.2	1.5	13.5	20.3	6.8	8
U (m/s)	0.879	0.169	0.271	1.088	0.817	14
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1026	713	300	1800	1500	1

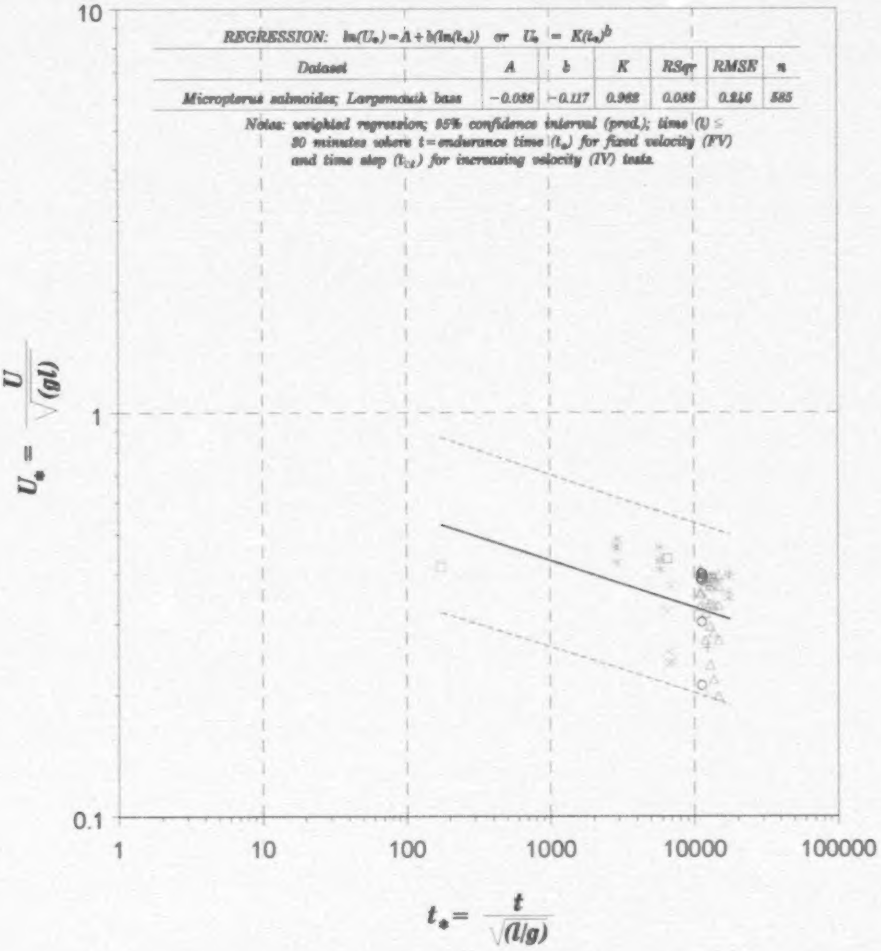


Figure C-066. Processed endurance data for Micropterus salmoides *(Largemouth Bass): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Dalberg et al. (1968); red triangles are data from Beamish (1970); green stars are data from Farlinger and Beamish (1977); black circles are data from Kolok (1991); turquoise diamonds are data from Kolok (1992a); blue crosses are data from Kolok (1992b); red x's are data from Cooke et al. (2001); black squares are data from Leavy and Bonner (2009).*

Table C-066. Data summary. Fish count 585, record count 58.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.128	0.048	0.032	0.26	0.228	18
T (C)	18.2	7.9	5	34	29	15
U (m[illegible])	0.375	0.098	0.2	0.65	0.45	54
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1114	474	10	1800	1790	6

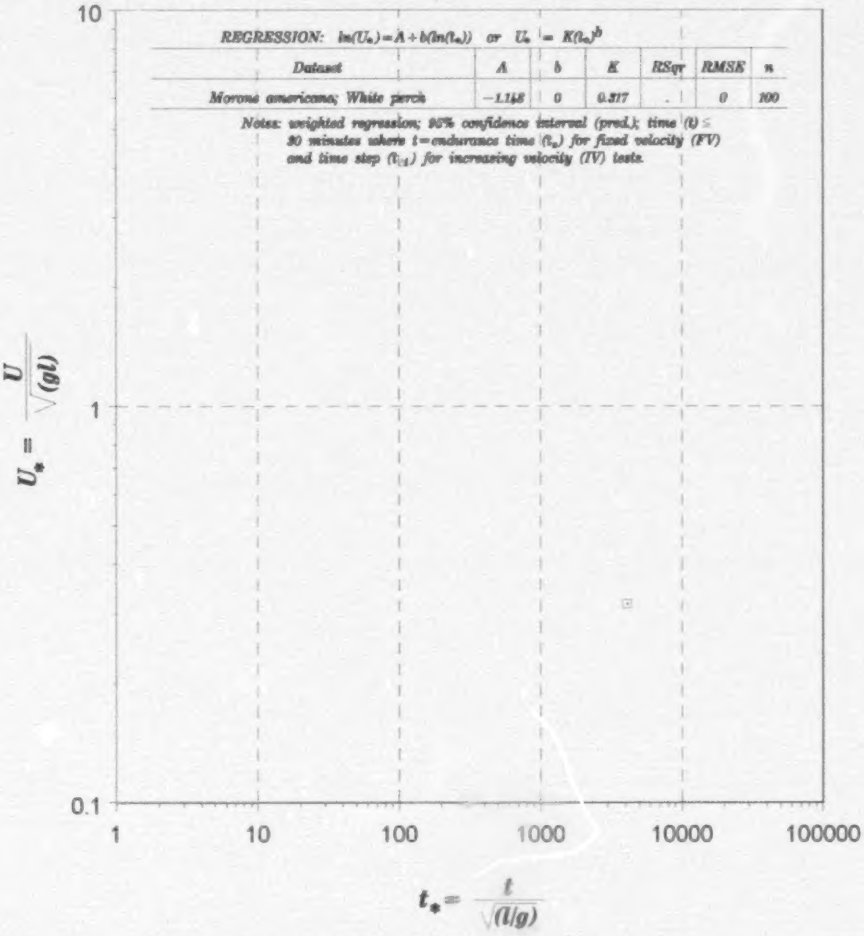


Figure C-067. Processed endurance data for Morone americana *(White Perch): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from from Mellas and Haynes (1985).*

Table C-067. Data summary. Fish count 100, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.264	0	0.76	0.267	0	1
T (C)	21.5	0	21.5	21.5	0	1
U (m/s)	0.51	0	0.51	0.51	0	1
t_e (s)	670	0	670	670	0	1
$t_{\Delta t}$ (s)	.	.	.	.	.	0

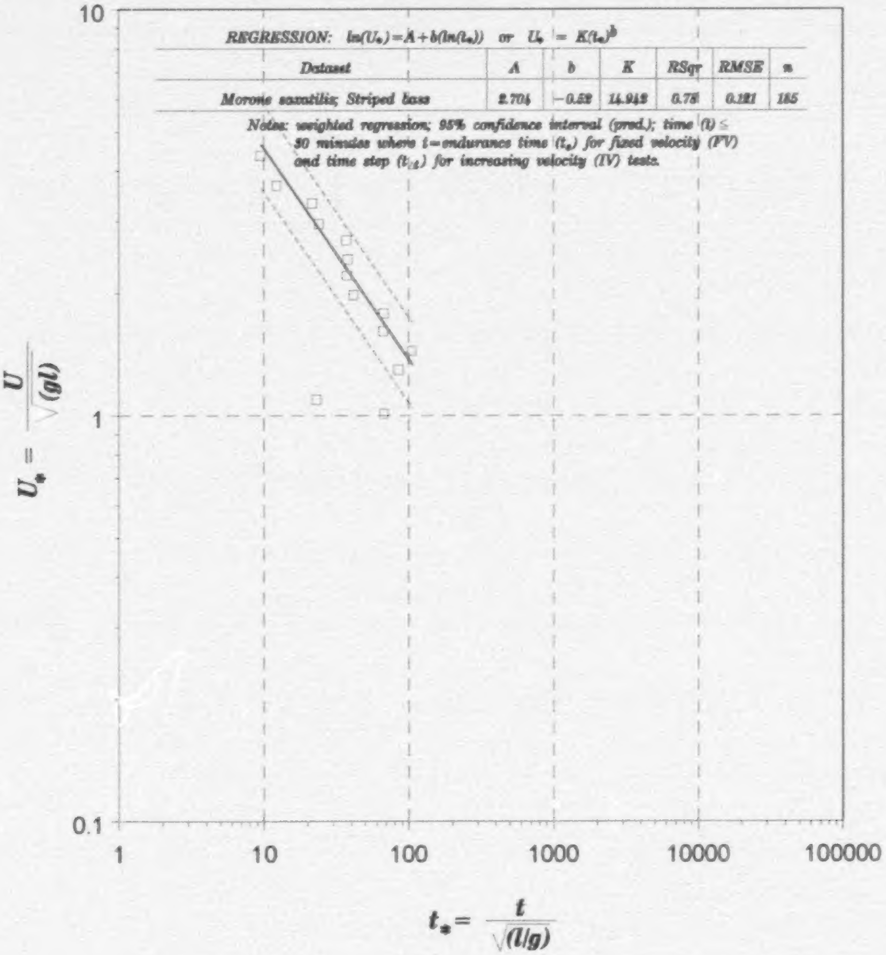


Figure C-068. Processed endurance data for Morone saxatilis *(Striped Bass): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Castro-Santos (2005).*

Table C-068. Data Summary. Fish Count: 100, record Count: 1

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.478	0	0.478	0.478	0	5
T (C)	18.9	0	18.9	18.9	0	1
U (m/s)	4.66	1.209	2.185	9.45	7.265	14
t_e (s)	11	5	2	23	21	14
$t_{\Delta t}$ (s)	.	.	.	.	.	0

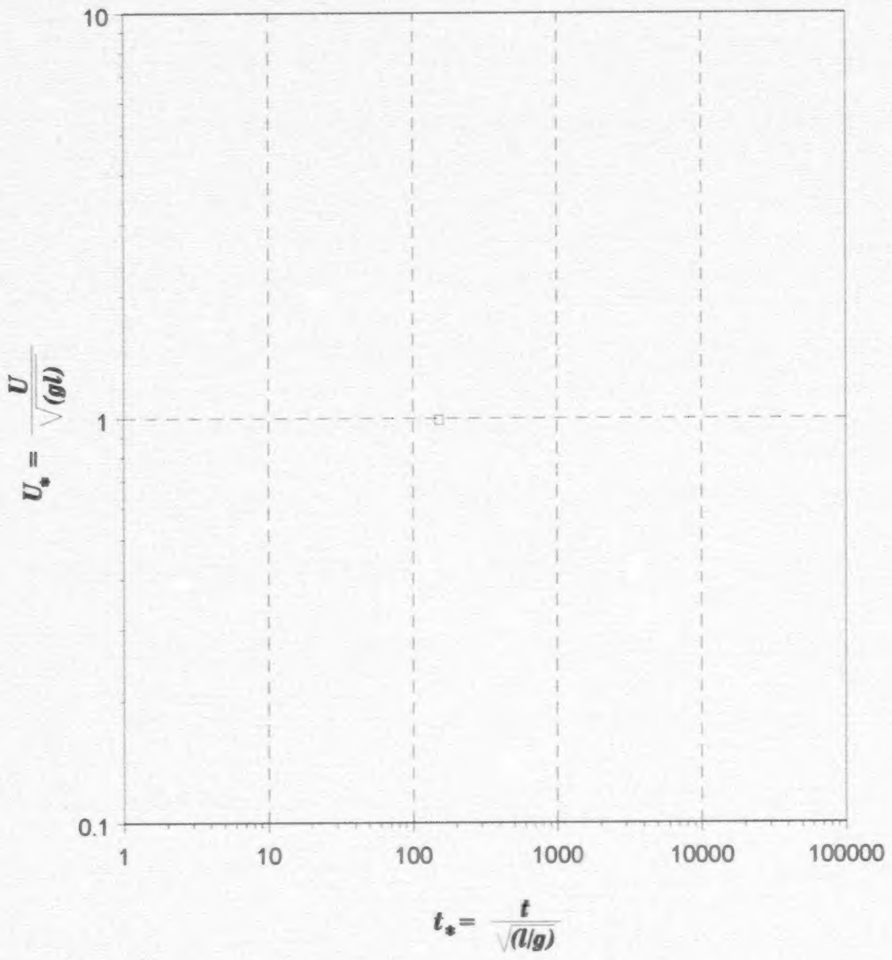


Figure C-069. Processed endurance data for Notropis amabilis *(Texas Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-069. Data summary. Fish count 29, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.042	0	1
T (C)	23.4	0	23.4	23.4	0	1
U (m/s)	0.636	0	0.636	0.636	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

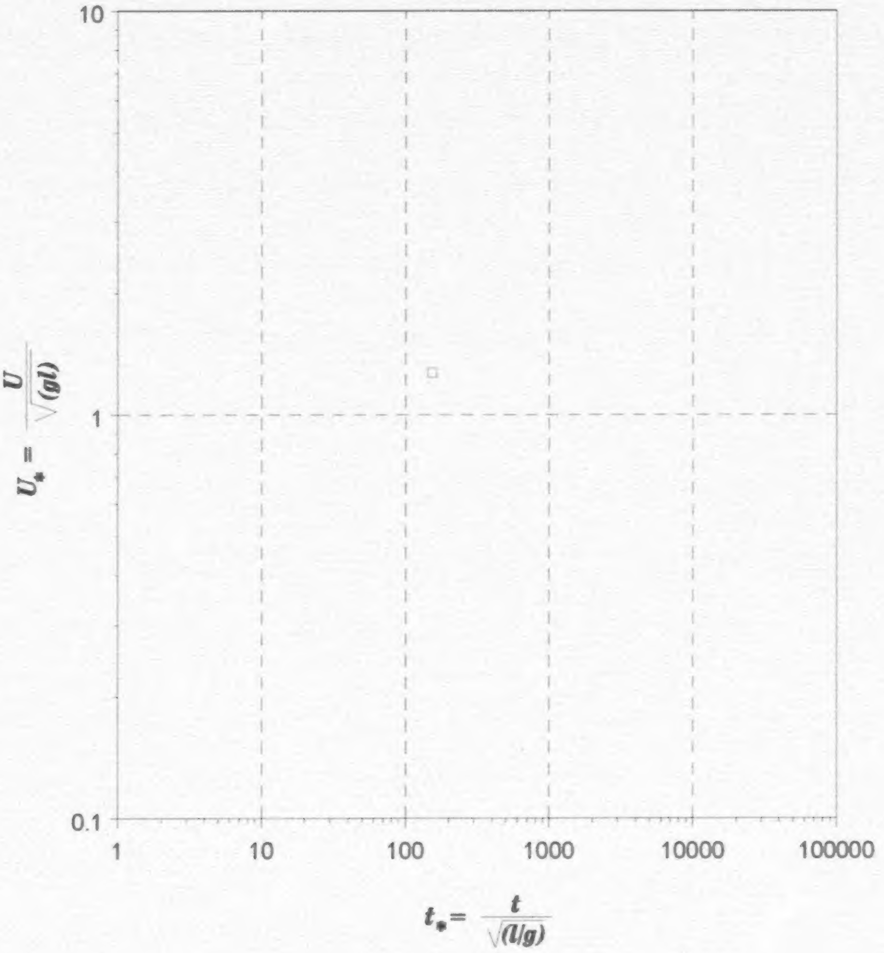


Figure C-070. Processed endurance data for Notropis atherinoides *(Emerald Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-070. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.042	0	1
T (C)	30	0	30	30	0	1
U (m/s)	0.814	0	0.814	0.814	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

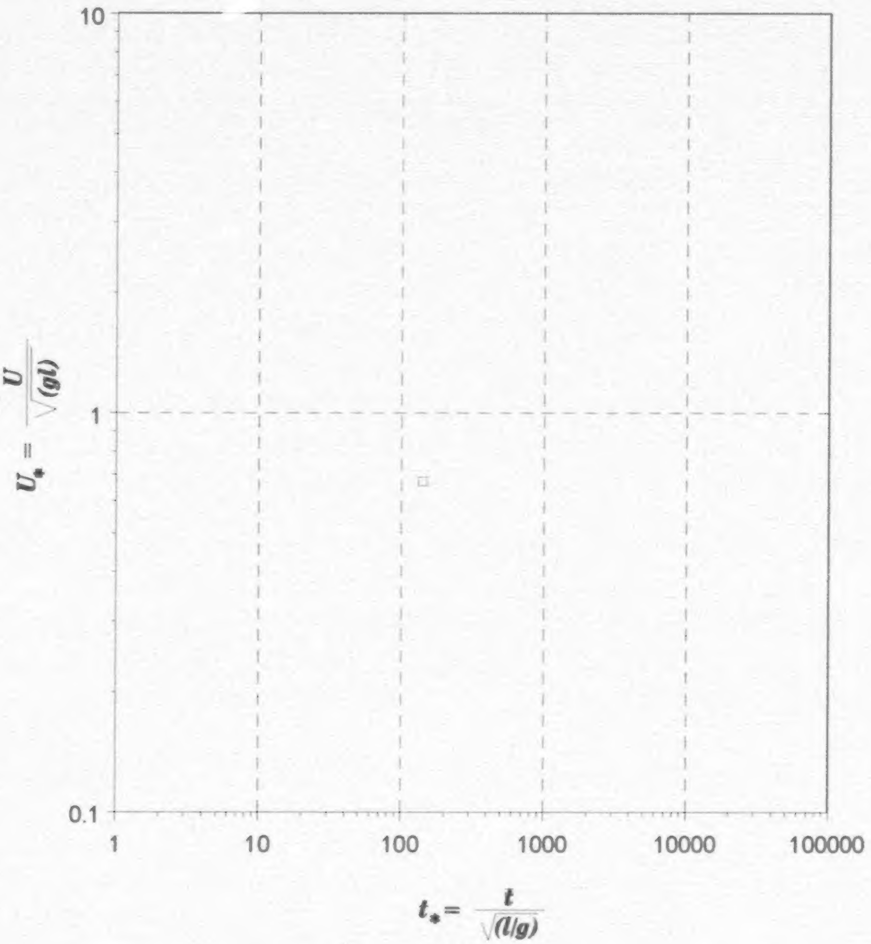


Figure C-071. Processed endurance data for Notropis atrocaudalis *(Blackspot Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-071. Data summary. Fish count 11, record count 1.

Variables	**Mean**	**SD**	**Min**	**Max**	**Range**	**N**
l (m)	0.05	0	0.05	0.05	0	1
T (C)	26.7	0	26.7	26.7	0	1
U (m/s)	0.469	0	0.469	0.469	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

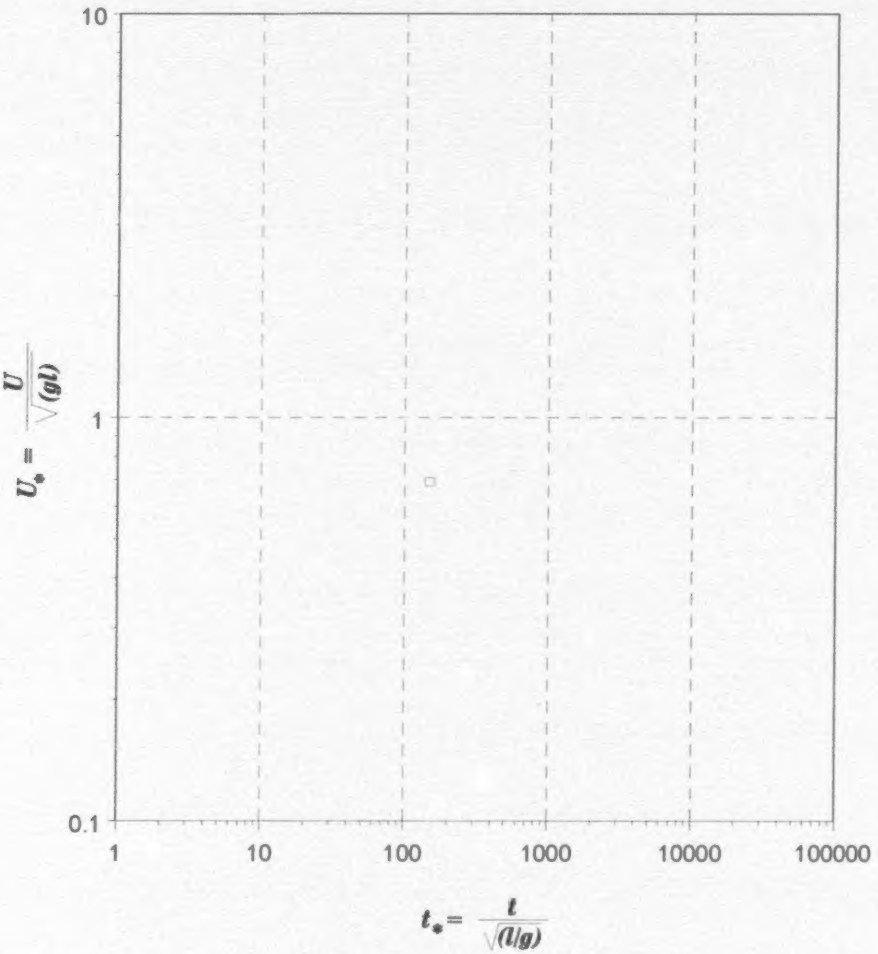


Figure C-072. Processed endurance data for Notropis bairdi *(Red River Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-072. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.044	0	0.044	0.044	0	1
T (C)	25.8	0	25.8	25.8	0	1
U (m/s)	0.456	0	0.456	0.456	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

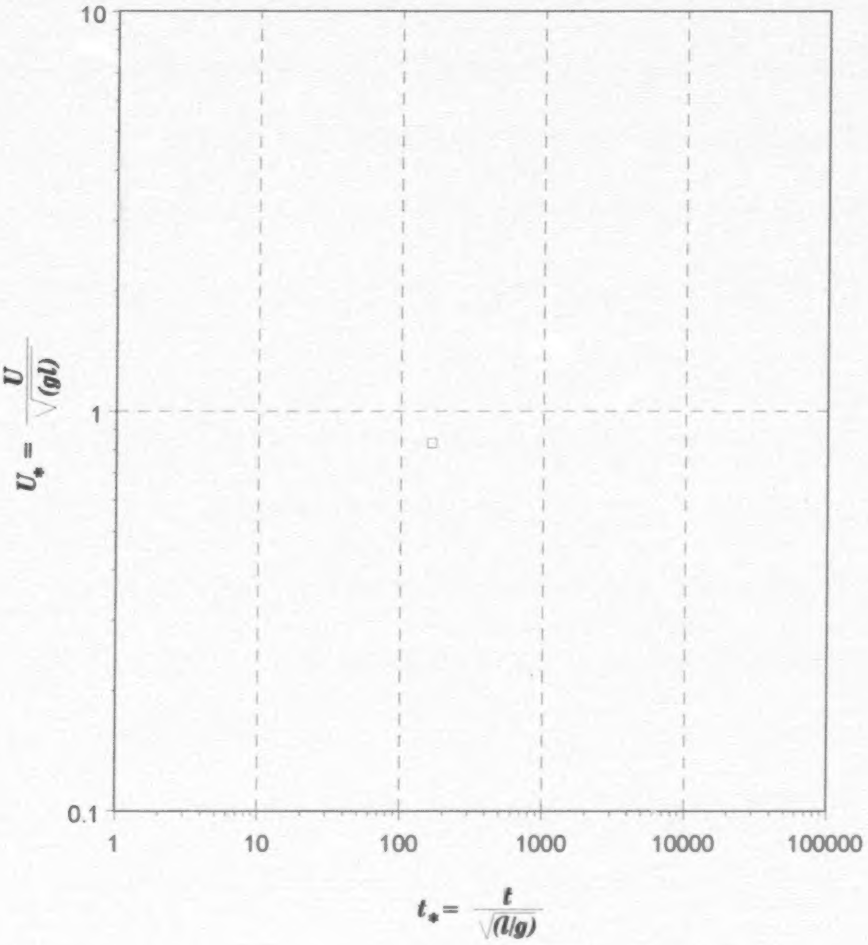


Figure C-073. Processed endurance data for Notropis buccula *(Smalleye Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-073. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.036	0	0.036	0.036	0	1
T (C)	32.9	0	32.9	32.9	0	1
U (m/s)	0.497	0	0.497	0.497	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

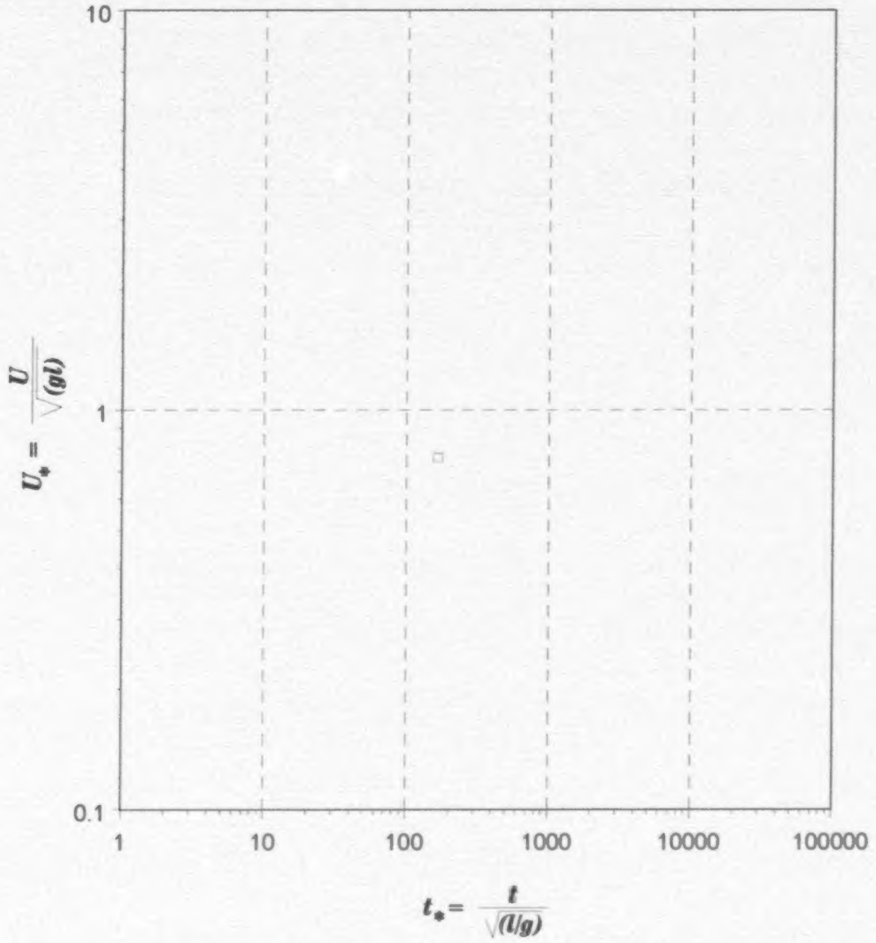


Figure C-074. Processed endurance data for Notropis buchanani *(Ghost Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-074. Data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	25.9	0	25.9	25.9	0	1
U (m/s)	0.447	0	0.447	0.447	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

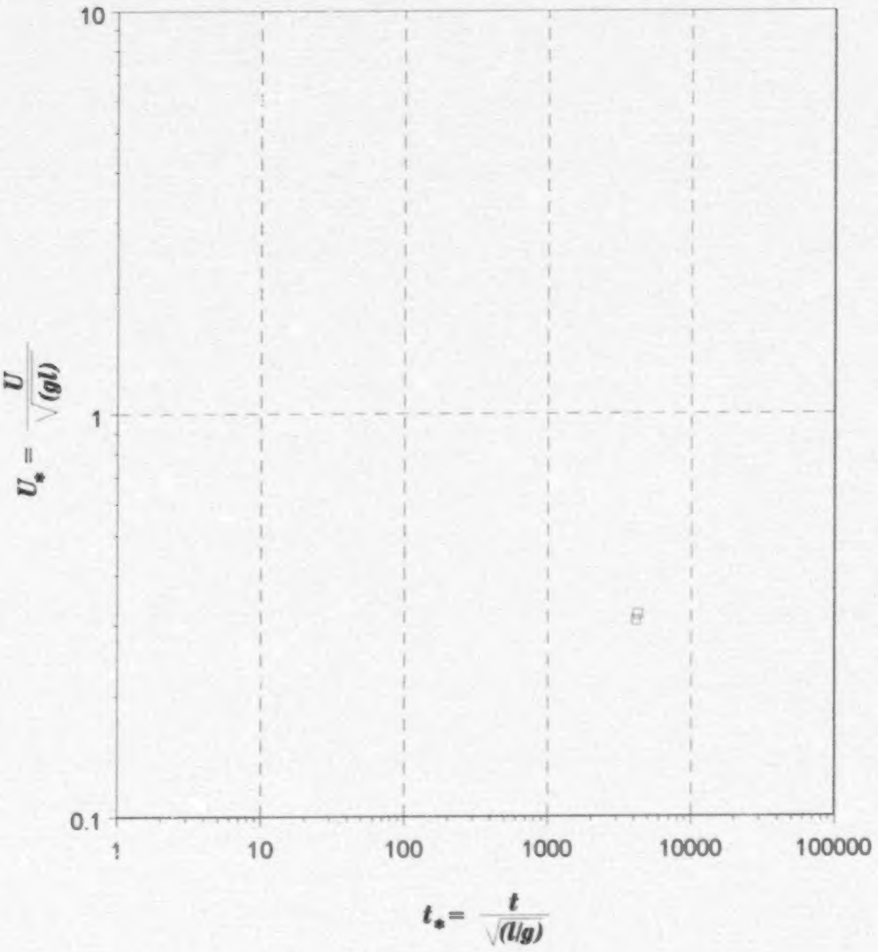


Figure C-075. Processed endurance data for Notropis hudsonius *(Spottail Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Goertzen (2011).*

Table C-075. Data summary. Fish count 32, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.051	0.002	0.049	0.052	0.003	2
T (C)	12	0	12	12	0	1
U (m/s)	0.22	0.001	0.219	0.221	0.002	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

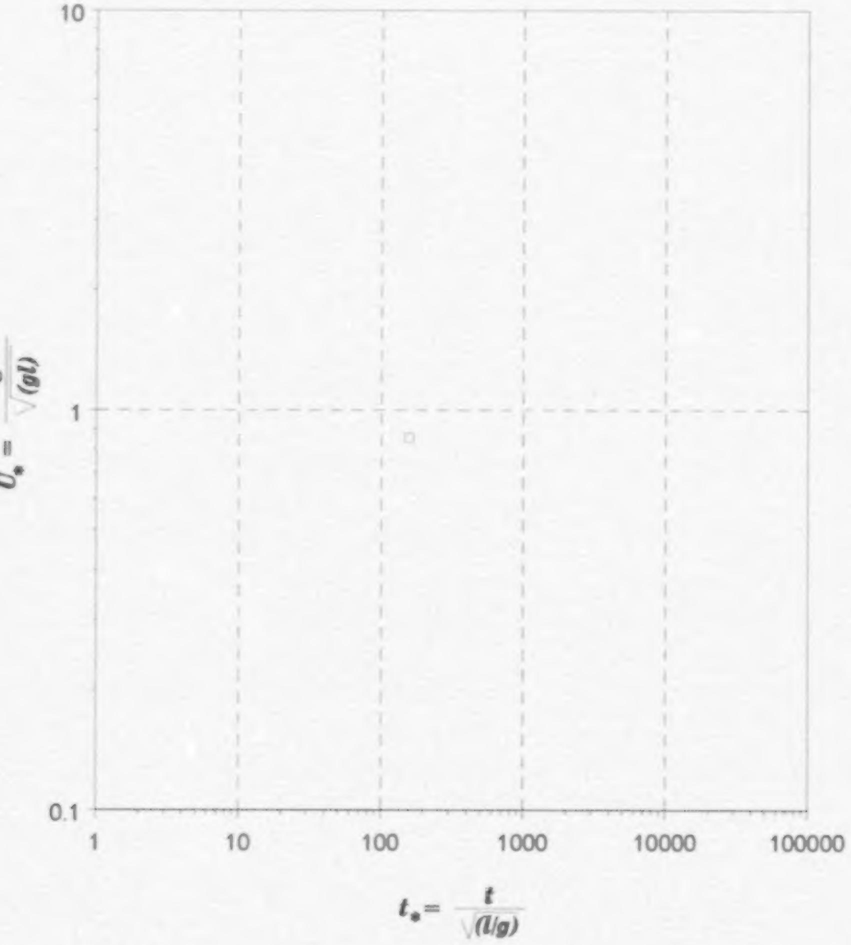


Figure C-076. Processed endurance data for Notropis oxyrhynchus *(Sharpnose Shiner): dimensionless swim speed (U^*) versus dimensionless time-to-fatigue (t^*). Blue square is data from Leavy and Bonner (2009).*

Table C-076. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0	0.04	0.04	0	1
T (C)	32.9	0	32.9	32.9	0	1
U (m/s)	0.534	0	0.534	0.534	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

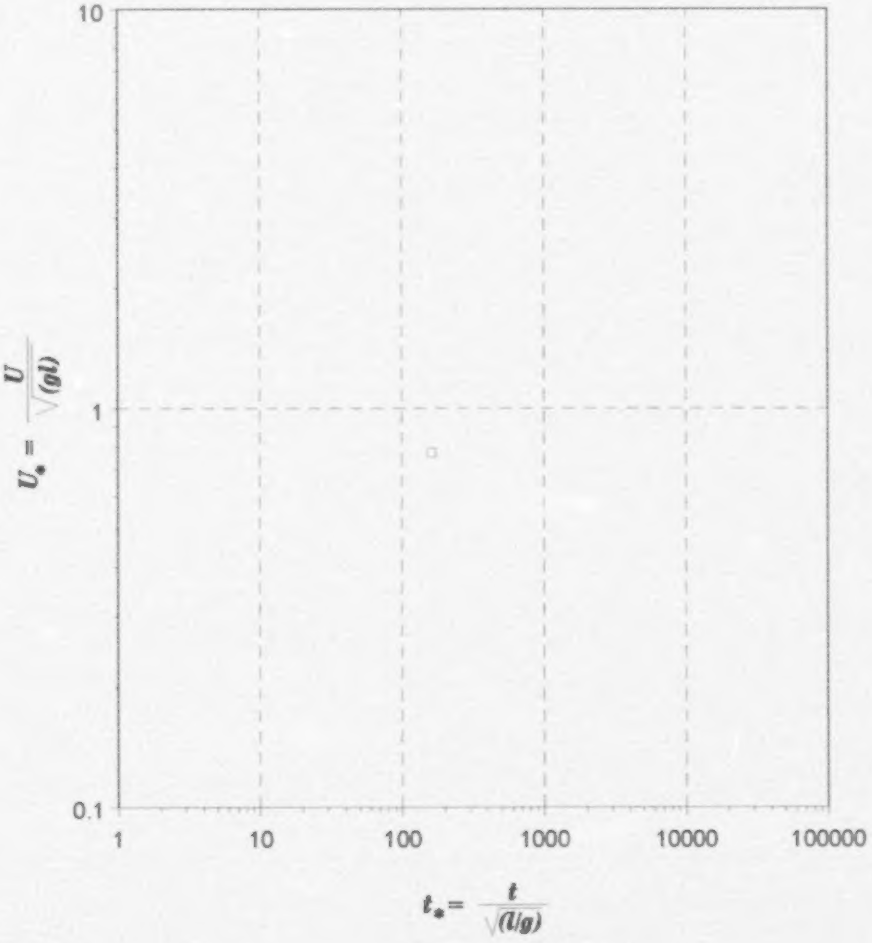


Figure C-077. Processed endurance data for Notropis sabinae *(Sabine Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-077. Data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.038	0	0.038	0.038	0	1
T (C)	27.4	0	27.4	27.4	0	1
U (m/s)	0.469	0	0.469	0.469	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

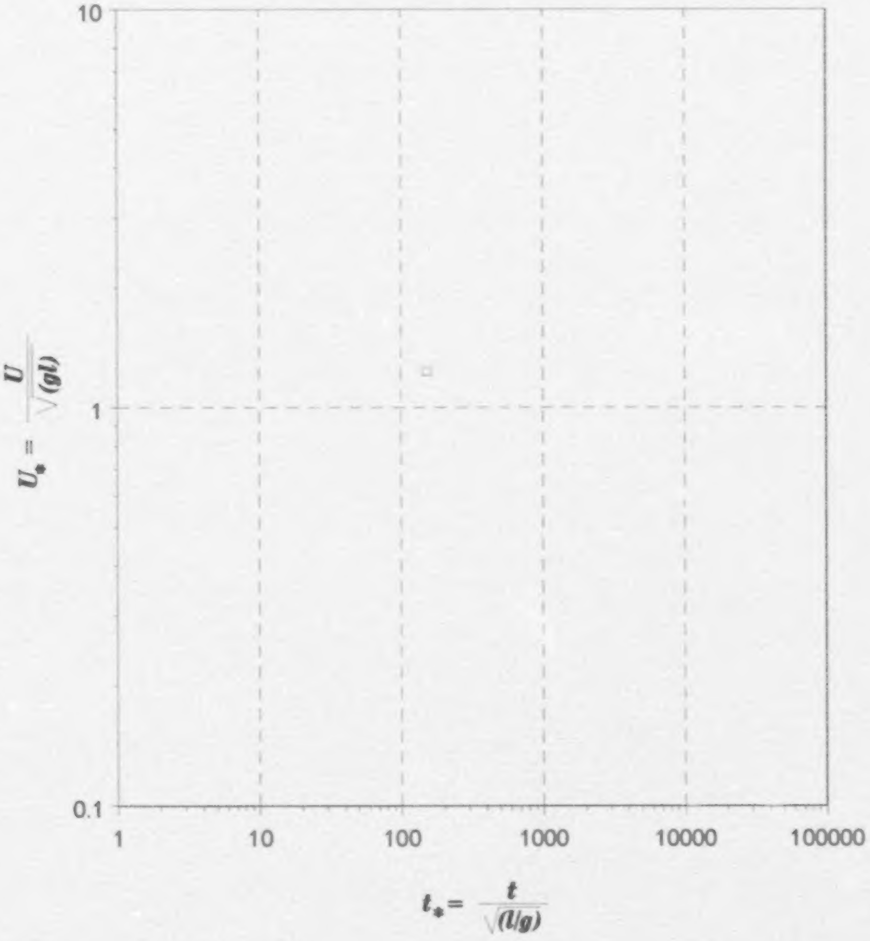


Figure C-078. Processed endurance data for Notropis shumardi *(Silverband Shiner): imensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-078. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.042	0	0.042	0.042	0	1
T (C)	30.5	0	30.5	30.5	0	1
U (m/s)	0.794	0	0.794	0.794	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

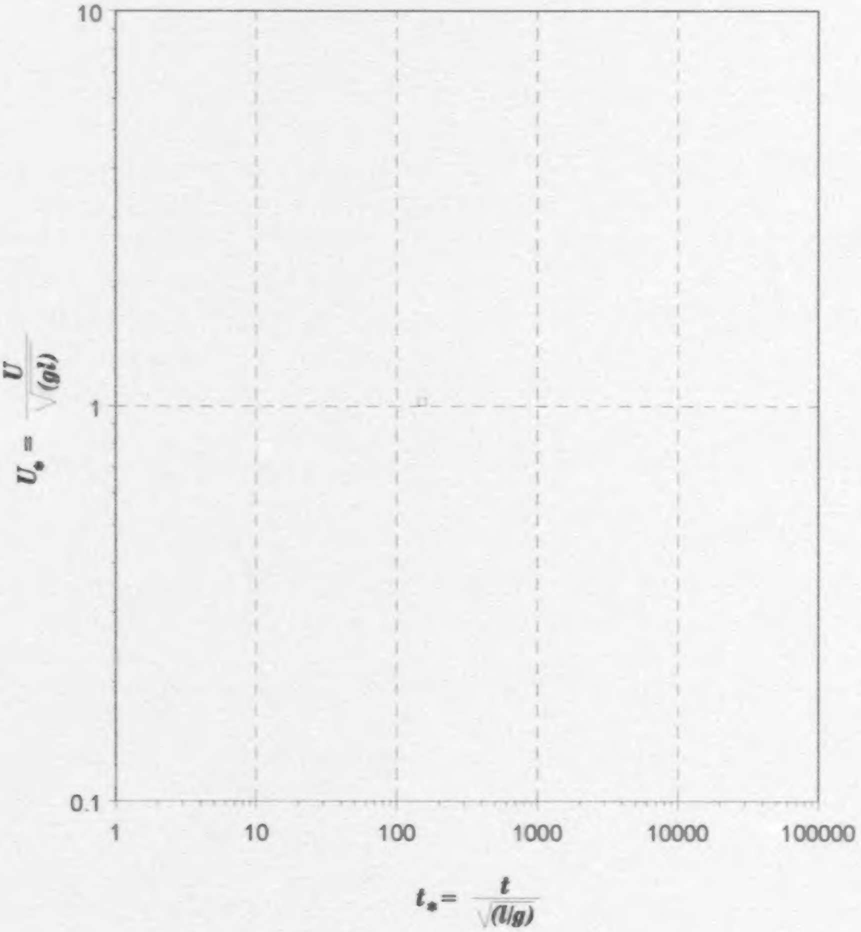


Figure C-079. Processed endurance data for Notropis stramineus *(Sand Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-079. Data summary. Fish count 18, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	28.4	0	28.4	28.4	0	1
U (m/s)	0.665	0	0.665	0.665	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

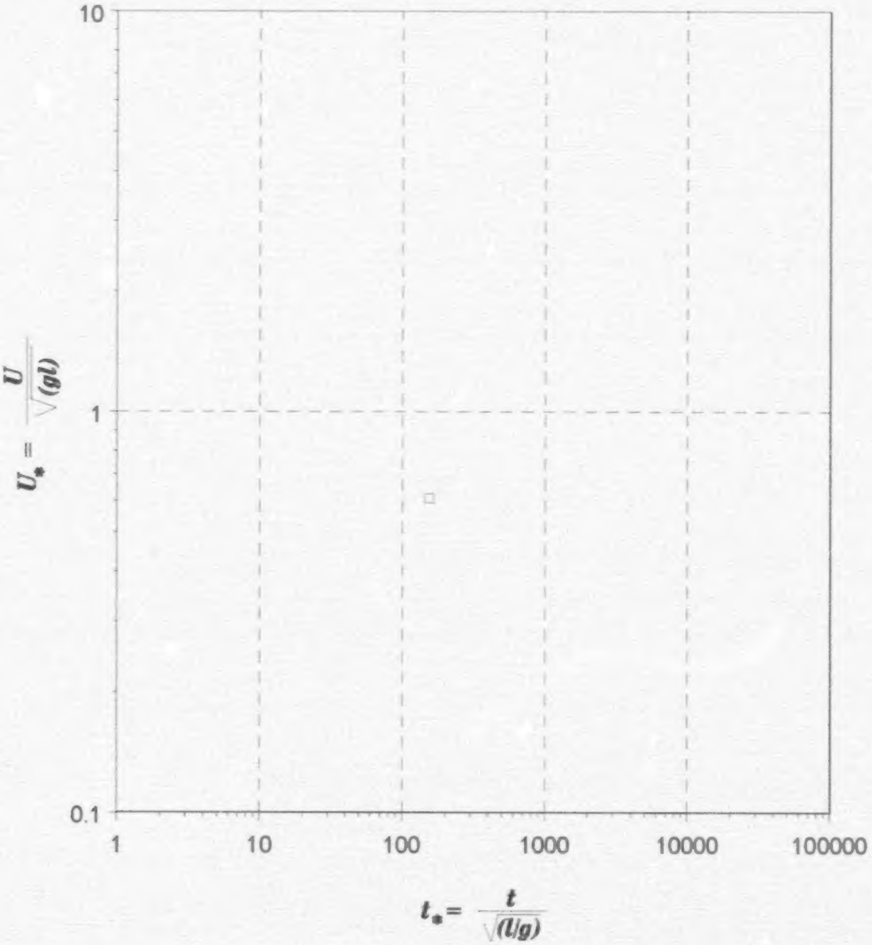


Figure C-080. Processed endurance data for Notropis texanus *(Weed Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-080. Data summary. Fish count 7, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.041	0	0.041	0.041	0	1
T (C)	27.3	0	27.3	27.3	0	1
U (m/s)	0.387	0	0.387	0.387	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

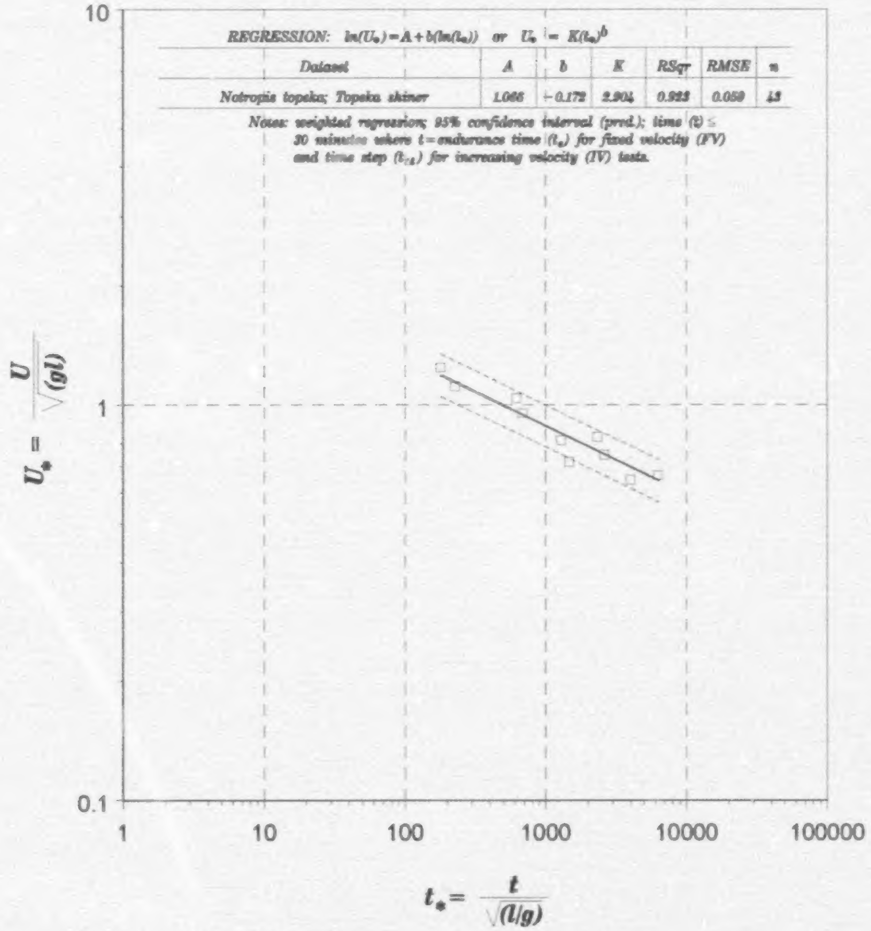


Figure C-081. Processed endurance data for Notropis topeka *(Topeka Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Adams et al. (2000).*

Table C-081. Data summary. Fish count 43, record count 10.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.04	0.005	0.037	0.05	0.013	2
T (C)	20	0	20	20	0	1
U (m/s)	0.559	0.113	0.4	0.75	0.35	8
t_e (s)	118	124	11	385	374	10
$t_{\Delta t}$ (s)	.	.	.	.	.	0

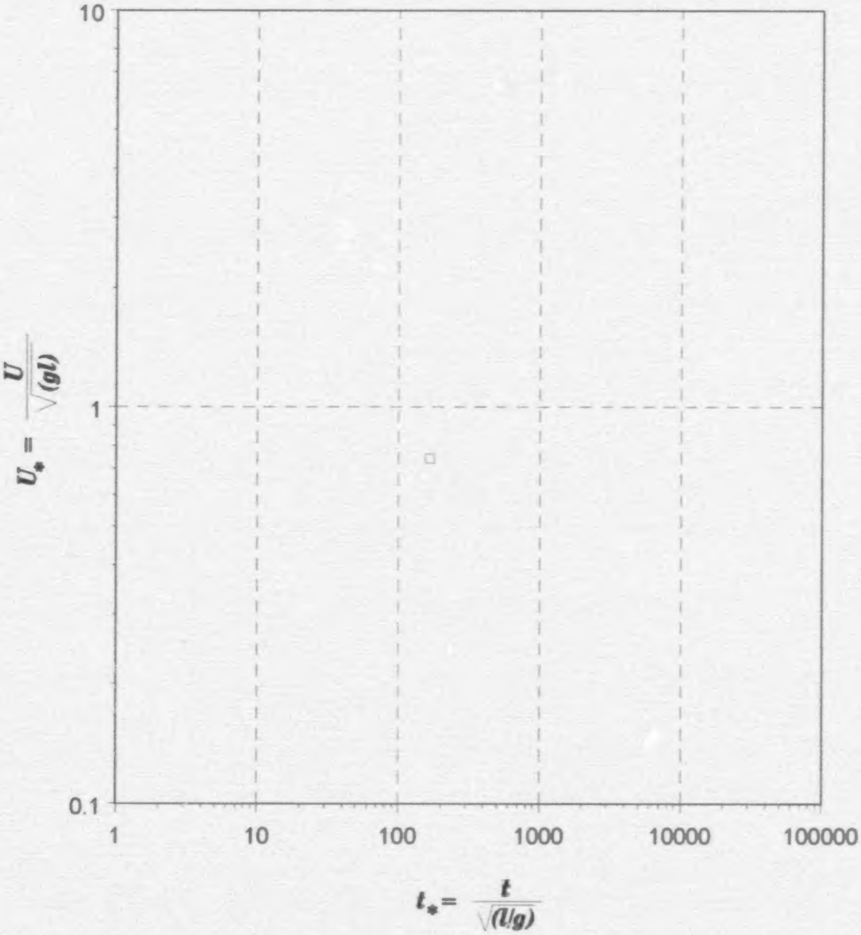


Figure C-082. Processed endurance data for Notropis volucellus *(Mimic Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-082. Data summary. Fish count 15, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	27.8	0	27.8	27.8	0	1
U (m/s)	0.436	0	0.436	0.436	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

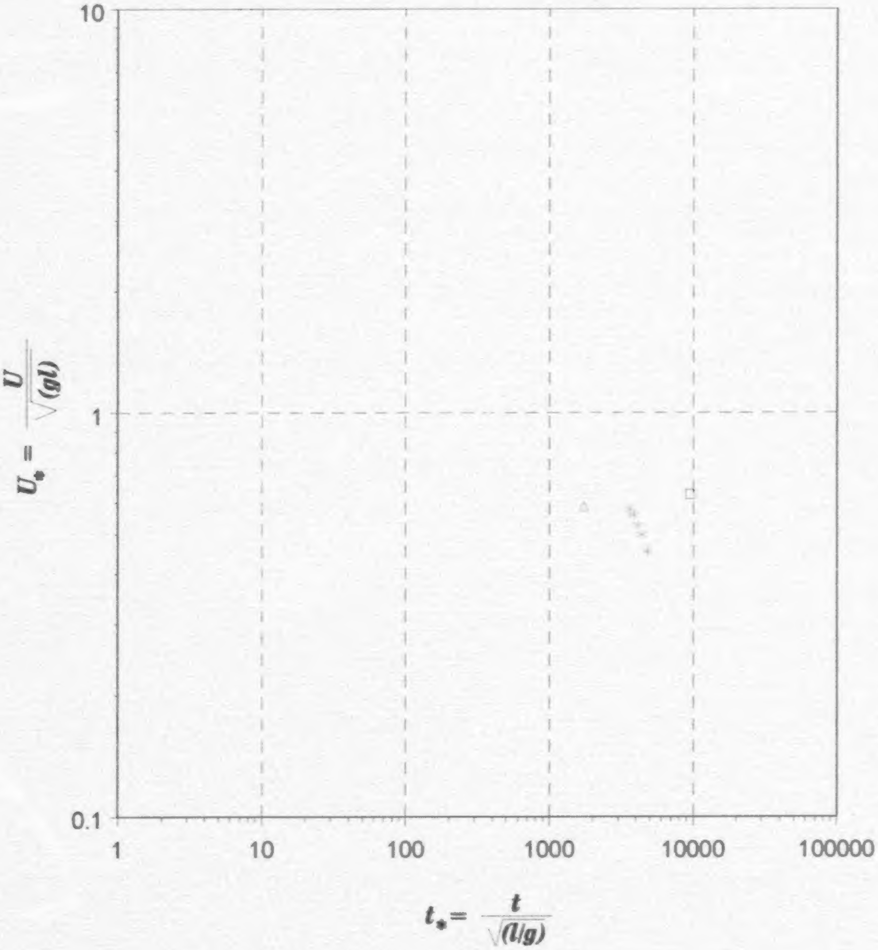


Figure C-083. Processed endurance data for Oncorhynchus clarki *(Cutthroat Trout): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Hawkins and Quinn (1996); red triangles are data from Zale et al. (2005), and green stars are data from Aedo et al. (2009).*

Table C-083. Data summary. Fish count 161, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.099	0.055	0.038	0.24	0.202	7
T (C)	17.8	2	13	19	6	3
U (m/s)	0.578	0.148	0.277	0.9	0.623	7
t_e (s)	272	0	272	272	0	1
$t_{\Delta t}$ (s)	734	269	300	900	600	2

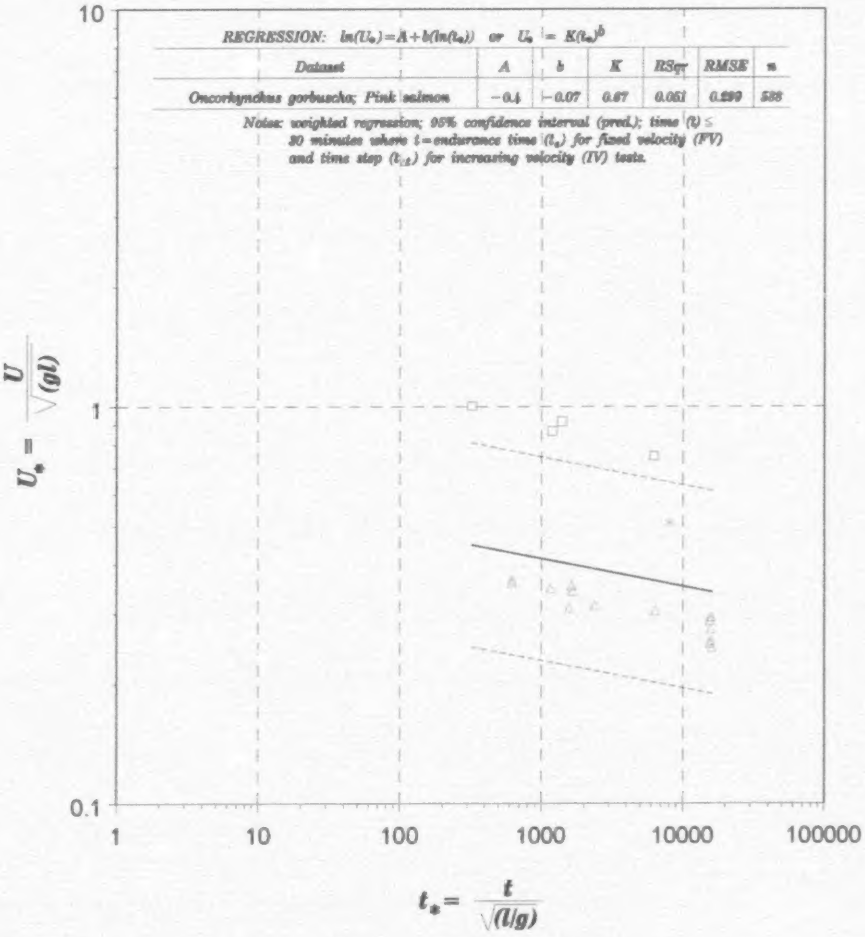


Figure C-084. Processed endurance data for Oncorhynchus gorbuscha *(Pink Salmon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Brett (1982); red triangles are data from Smith and Carpenter (1987); green stars are data from Williams and Brett (1987).*

Table C-084. Data summary. Fish count 588, record count 19.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.188	0.217	0.031	0.574	0.543	8
T (C)	9	308	4	20	16	5
U (m/s)	0.518	0.508	0.136	2.38	2.244	13
t_e (s)	300	378	35	1508	1473	11
$t_{\Delta t}$ (s)	1372	450	900	1800	900	2

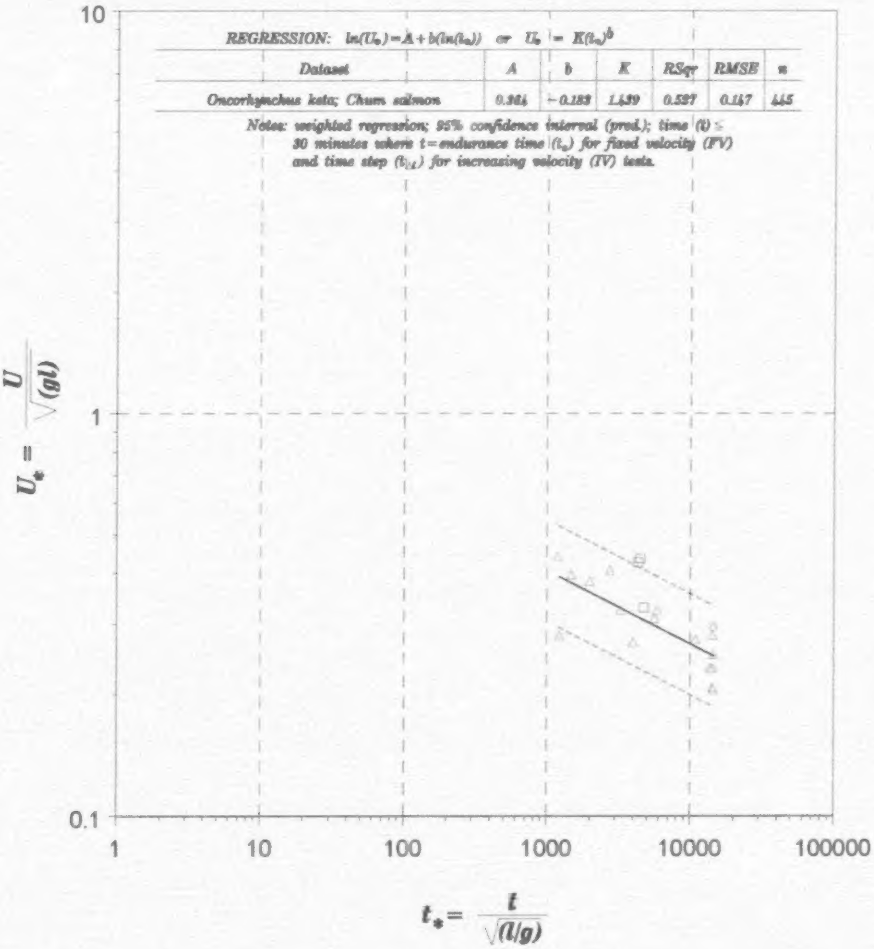


Figure C-085. Processed endurance data for Oncorhynchus keta *(Chum Salmon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Houston (1959); red triangles are data from Smith and Carpenter (1987).*

Table C-085. Data summary. Fish count 445, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.039	0.002	0.038	0.048	0.01	7
T (C)	7.1	2.5	4	10	6	3
U (m/s)	0.177	0.042	0.126	0.291	0165	15
t_e (s)	436	325	75	900	825	12
$t_{\Delta t}$ (s)	851	165	300	900	600	2

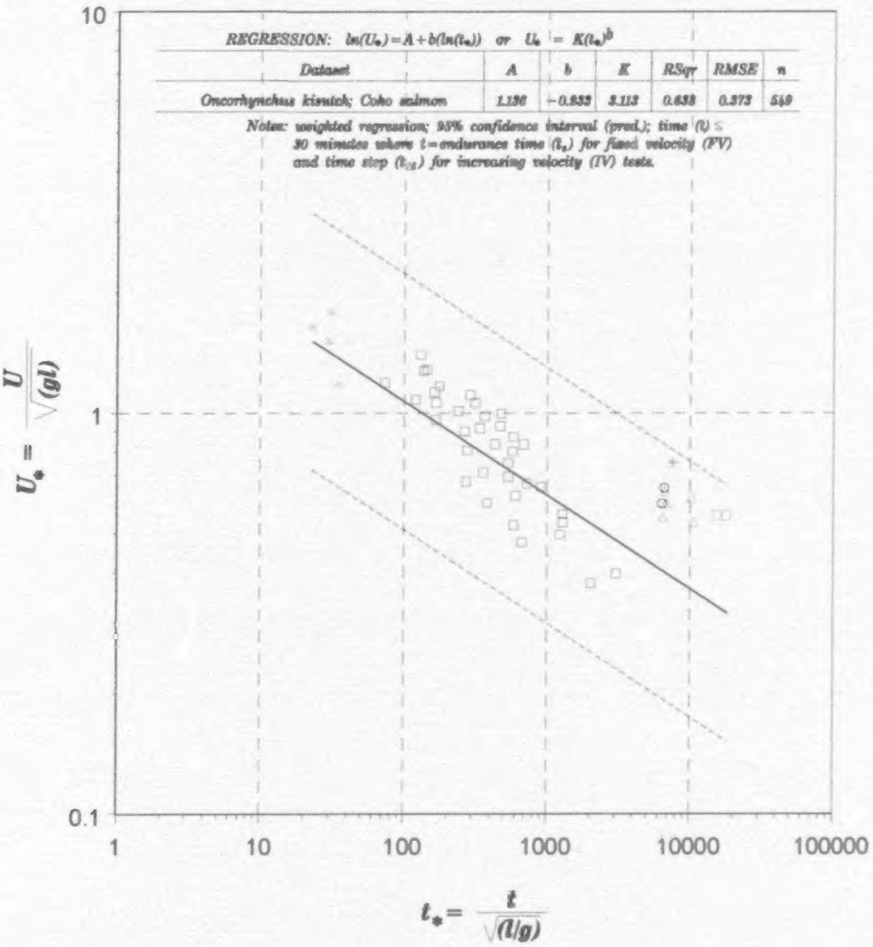


Figure C-086. Processed endurance data for Oncorhynchus kisutch *(Coho Salmon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Paulik and DeLacy (1957); red triangles are data from Davis et al. (1963); green stars are data from Weaver (1963); black circles are data from Dahlberg et al. ((1968); turquoise diamonds are data from Smith and Carpenter (1987); blue crosses are data from MacKinnon and Farrell (1992); red Xs are data from Nikl and Farrell (1993); green squares are data from Brauner et al. (1994b).*

Table C-086. Data summary. Fish count 549, record count 60.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.218	0.244	0.034	0.75	0.716	41
T (C)	11.9	4.6	7	20.1	13.1	13
U (m/s)	1.024	1.166	0.131	4.059	3.928	31
t_e (s)	142	145	6	714	708	1 45
$t_{\Delta t}$ (s)	939	336	600	1800	1200	4

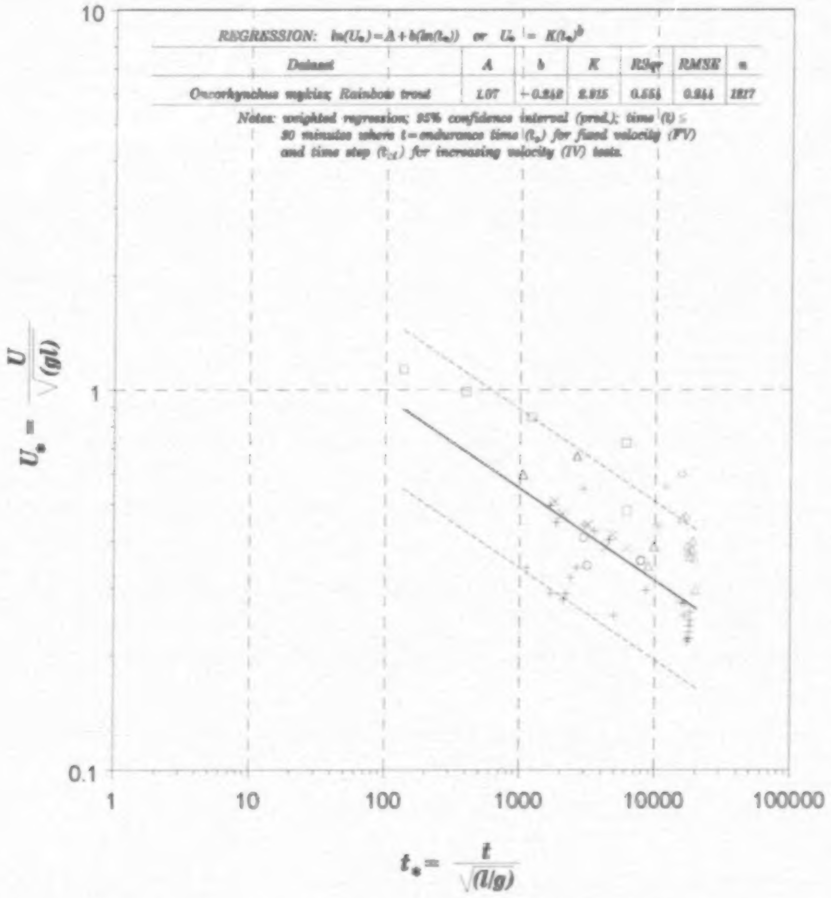


Figure C-087. Processed endurance data for Oncorhynchus mykiss *(Rainbow Trout):dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Tsukamoto et al. (1975); red triangles are data from Beamish (1980); green stars are data from Daxboeck (1982); black circles are data form Mellas and Haynes (1985); turquoise diamonds are data from Duthie and Hughes (1987); blue crosses are data from Smith and Carpenter (1987); red x's are data from Farrell et al. (1990); green squares are data from Farrell et al. (1991); black triangles are data from Gamperl et al. (1991), tuquoise stars are data from Pearson and Stevens (1991) ,blue circles are data from Gallaugher et al. (1992); red diamonds are data from Nikl and Farrell (1993), dark green crosses data are from Johansen et al. (1994); black x's are data from Mitton and McDonald (1994); turquoise squares are data from Anderson et al. (1997); blue triangles are data from Jain et al. (1997); red stars are data from Peake et al. (1997a); black crosses are data from McDonald et al.(1998.*

Table C-087. Data summary. Fish count 1217, record count 60.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.116	0.116	0.024	0.41	0.386	44
T (C)	11.1	3.5	6	18.5	12.5	17
U (m/s)	0.408	0.315	0.11	1.47	1.36	42
t_e (s)	538	417	18	1278	1260	22
$t_{\Delta t}$ (s)	763	544	120	1800	1680	6

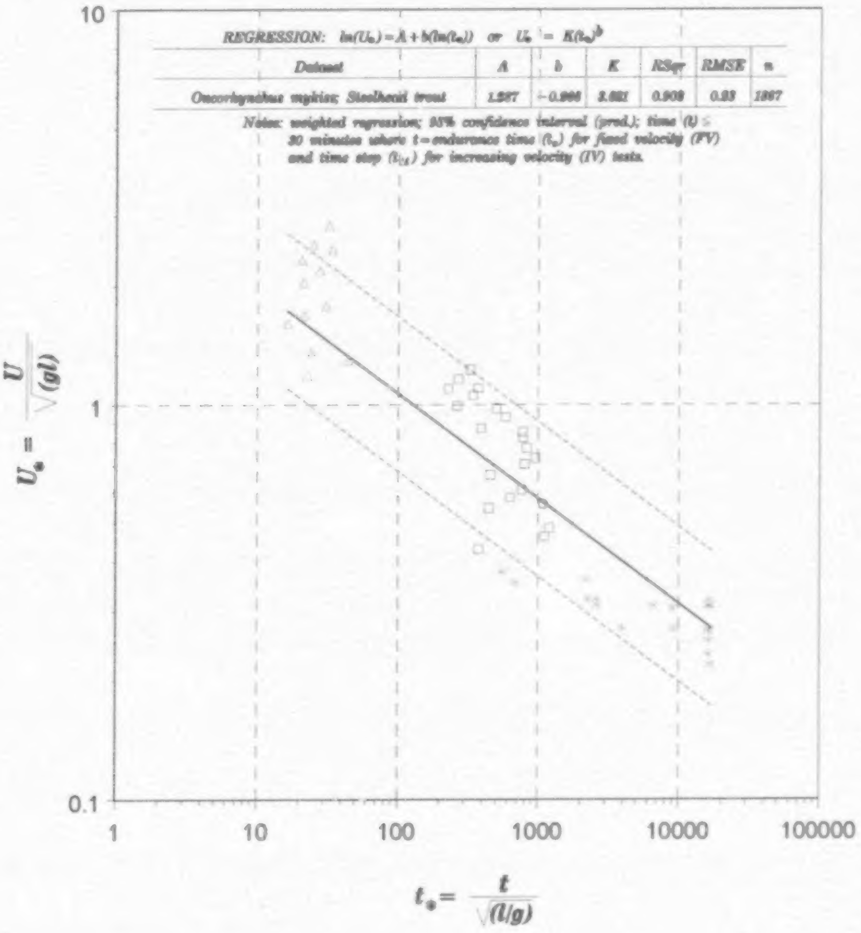


Figure C-088. Processed endurance data for Oncorhynchus mykiss *(Steelhead Trout): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Paulik and DeLacy (1957); red triangles are data from Weaver (1963); green stars are data from Smith and Carpenter (1987); black circles are data from Webb (1993); turquoise diamonds are data from Hawkins and Quinn (1996).*

Table C-088. Data summary. Fish count 1867, record count 54.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.45	0.271	0.028	0.82	0.792	26
T (C)	16.4	4.1	7	19	12	6
U (m/s)	2.751	1.772	0.115	6.406	6.291	31
t_e (s)	89	223	5	900	895	42
$t_{\Delta t}$ (s)	872	147	120	900	780	2

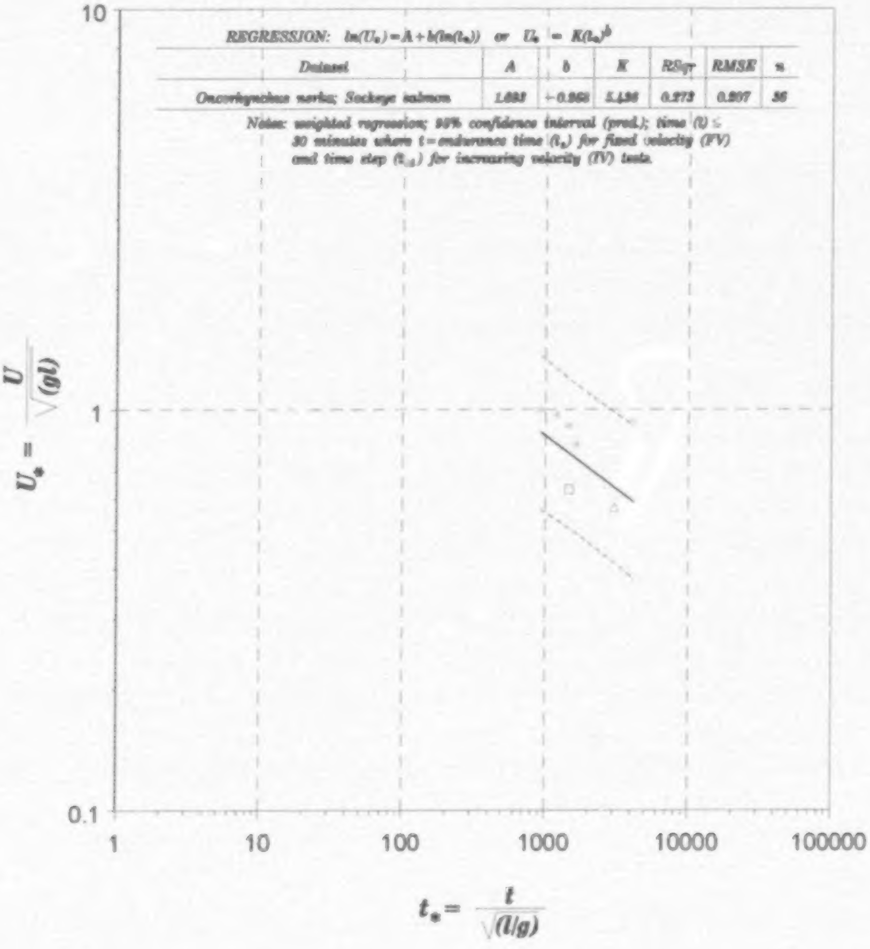


Figure C-089. Processed endurance data for Oncorhynchus nerka *(Sockeye Salmon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Brett (1964); red triangles are data from Brett (1967); green stars are data from Brett (1982).*

Table C-089. Data summary. Fish count 36, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.308	0.2	0.138	0.621	0.483	6
T (C)	15.1	3.1	10	18	8	3
U (m/s)	1.301	0.739	0.662	2.268	1.606	6
t_e (s)	353	193	196	942	746	6
$t_{\Delta t}$ (s)	.	.	.	.	.	0

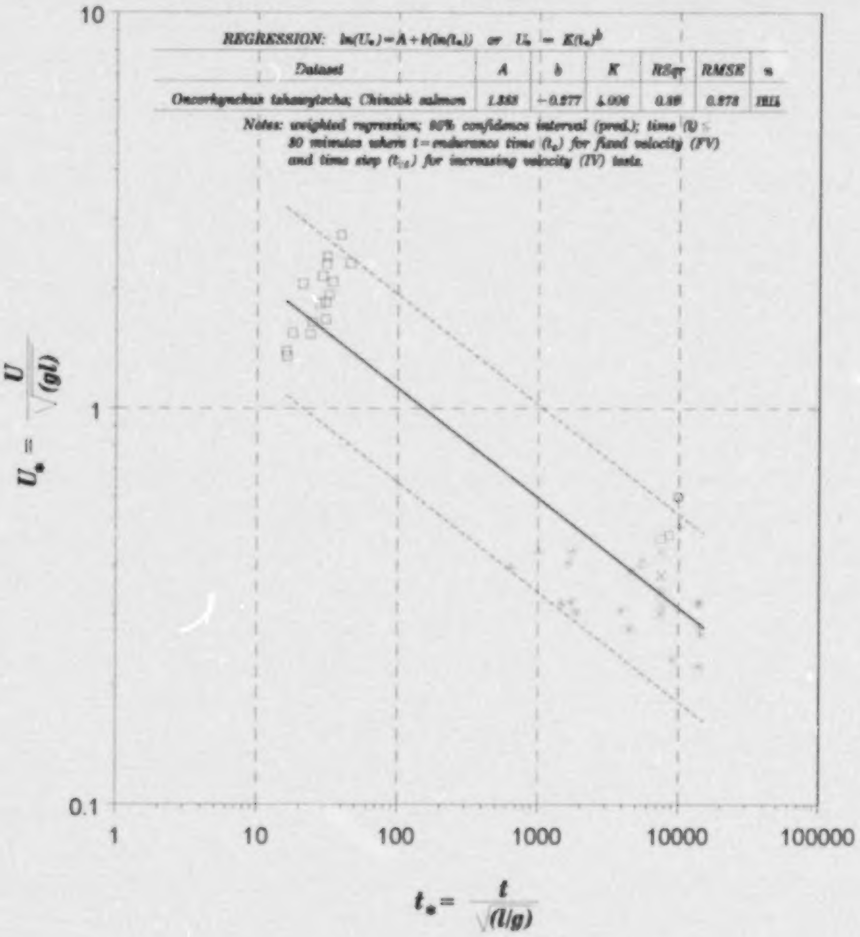


Figure C-090. Processed endurance data for Oncorhynchus tshawytscha *(Chinook Salmon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Weaver (1963); red triangles are data from Farrell and Steffensen (1987); green stars are data from Smith and Carpenter (1987); black circles are data from Brauner et al. (1993); turquoise diamonds are data from Nikl and Farrell (1993); blue crosses are data from Thorarensen (1993); red x's are data from Muir et al. (1994); green squares are data from Adams et al. (1998).*

Table C-090. Data summary. Fish count 1214, record count 46.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.325	0.303	0.038	0.927	0.889	16
T (C)	12.9	6	3.1	19	15.9	15
U (m/s)	2.047	1.999	0.14	6.223	6.083	38
t_e (s)	90	188	5	900	896	25
$t_{\Delta t}$ (s)	968	233	900	1800	900	3

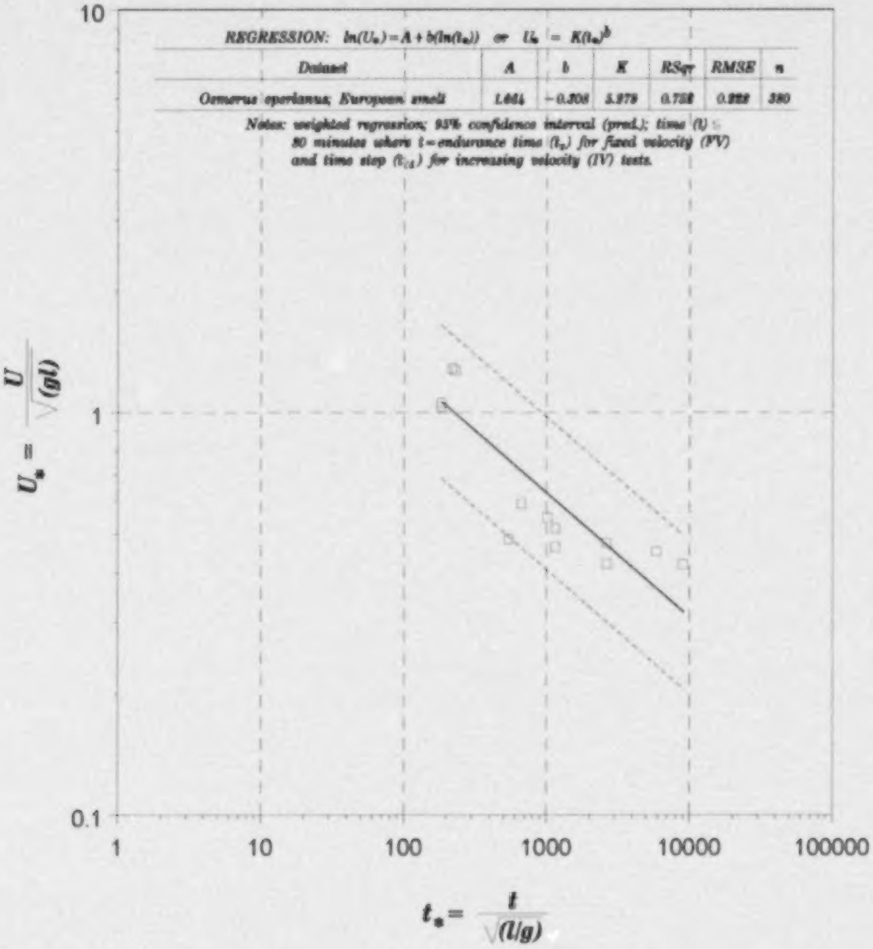


Figure C-091. Processed endurance data for Osmerus eperlanus *(European Smelt): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Clough et al. (2003).*

Table C-091. Data summary. Fish count 380, record count 13.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.098	0.018	0.074	0.12	0.046	11
T (C)	12	3.5	6	17.4	11.4	11
U (m/s)	0.787	0.324	0.375	1.154	0.779	8
t_e (s)	268	293	60	930	870	6
$t_{\Delta t}$ (s)	20	0	20	20	0	1

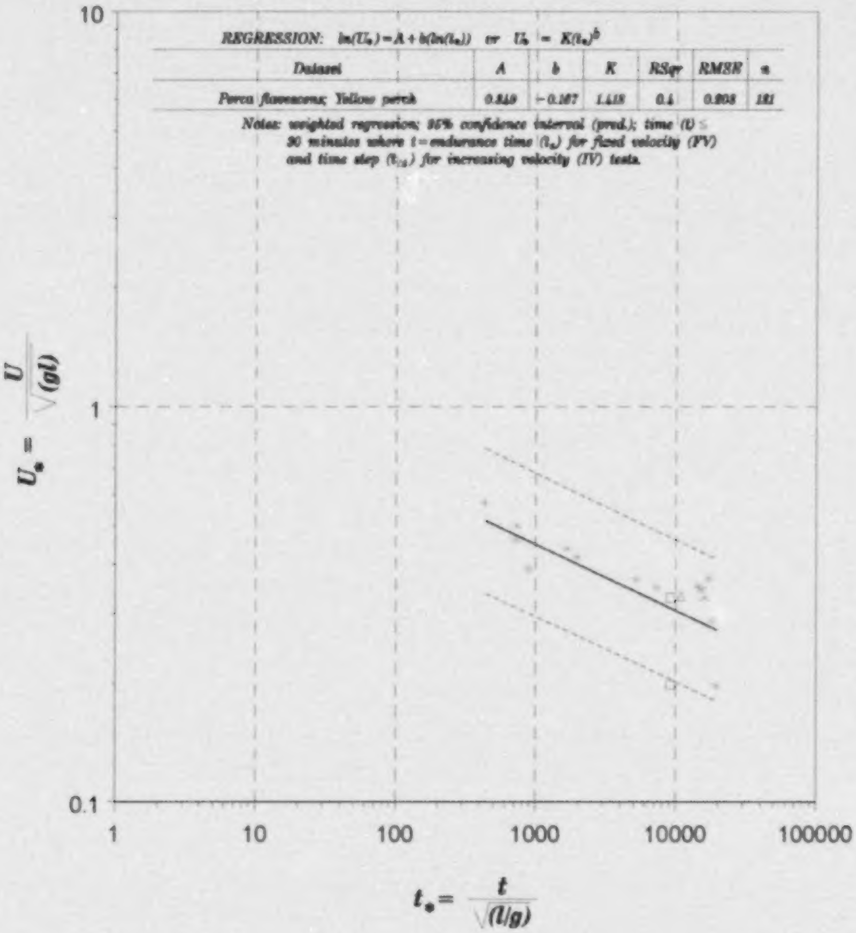


Figure C-092. Processed endurance data for Perca flavescens *(Yellow Perch): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Otto and O'Hare-Rice (1974); red triangles are data from McDonald et al. (1991); green stars are data from Taylor et al. (2004).*

Table C-092. Data summary. Fish count 131, record count 17.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.103	0.019	0.05	0.151	0.101	16
T (C)	18.9	4	10	21	11	4
U (m/s)	0.342	0.077	0.18	0.427	0.247	9
t_e (s)	300	257	31	854	823	8
$t_{\Delta t}$ (s)	1292	433	900	1800	900	3

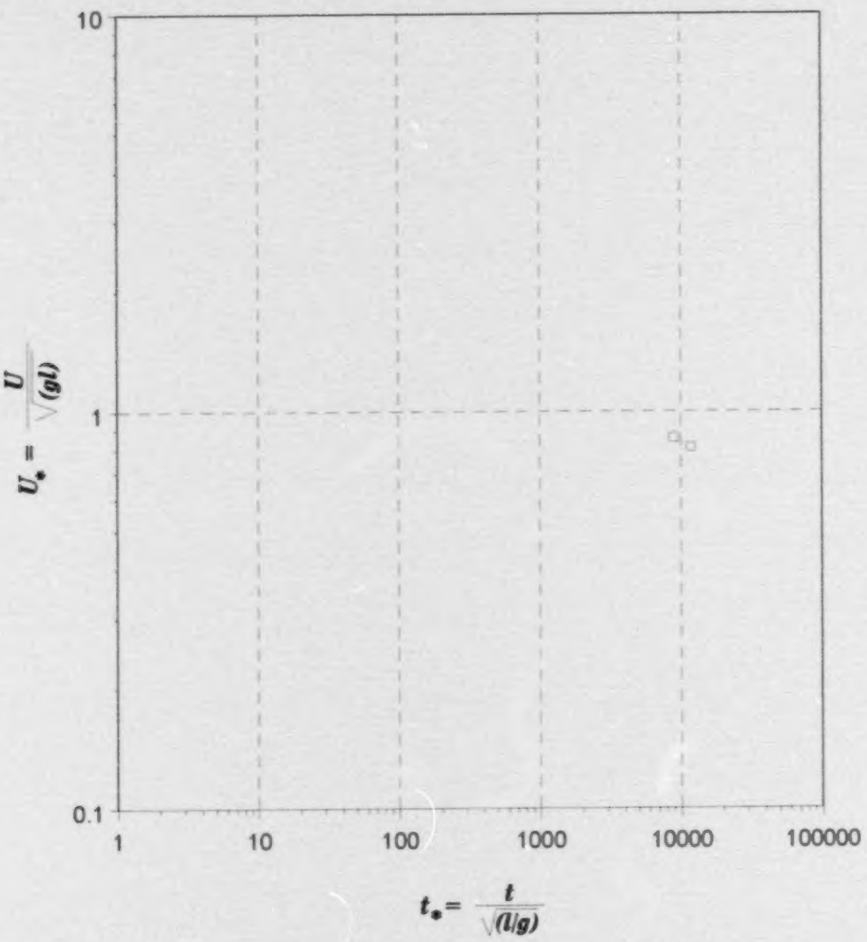
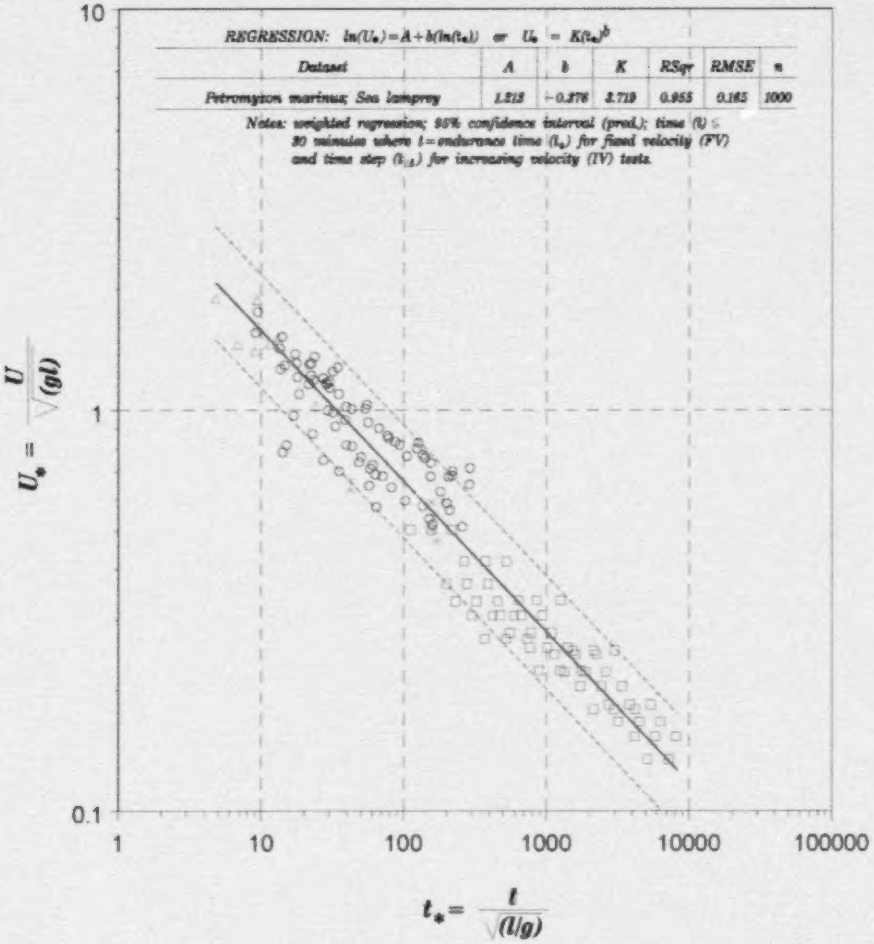


Figure C-093. Processed endurance data for Perca fluviatilis *(European Perch): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Tudorache et al. (2008).*

Table C-093. Data summary. Fish count 16, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.14	0.04	0.101	0.178	0.077	2
T (C)	15	0	15	15	0	1
U (m/s)	0.968	0.168	0.806	1.13	0.325	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Petromyzon marinus; Sea lamprey	1.313	−0.376	3.719	0.955	0.165	1000

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure C-094. Processed endurance data for Petromyzon marinus *(Sea Lamprey): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Beamish (1974); red triangles are data from Hanson (1980); green stars are data from Bergstedt et al. (1981); black circles are data from McAuley (1996).*

Table C-094. Data summary. Fish count 1000, record count 151.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.392	0.124	0.145	0.59	0.445	65
T (C)	12.4	5.1	5	23	18	55
U (m/s)	1.265	1.11	0.3	3.961	3.661	89
t_e (s)	216	343	1	1635	1634	99
$t_{\Delta t}$ (s)	.	.	.	.	.	0

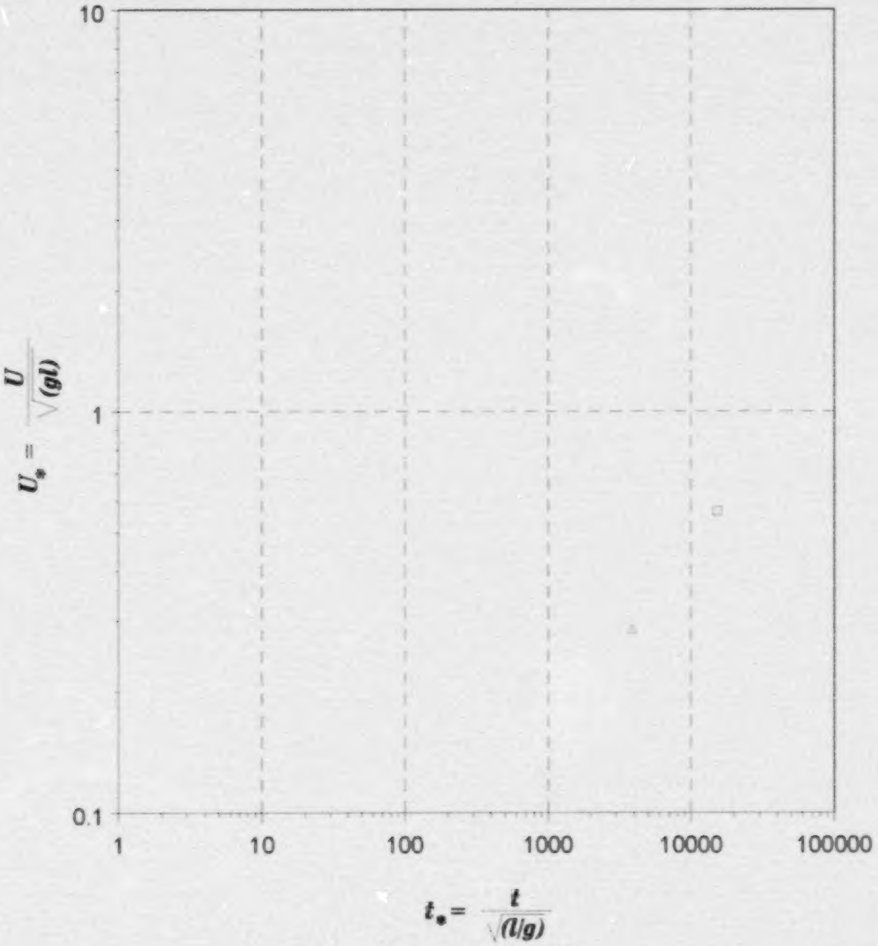


Figure C-095. Processed endurance data for Pimephales promelas *(Fathead Minnow): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Kolok et al. (1998); red triangle is data from Goertzen (2011).*

Table C-095. Data summary. Fish count 75, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.047	0.019	0.021	0.061	0.04	2
T (C)	22.6	1.9	20	24	4	2
U (m/s)	0.329	0.146	0.13	0.435	0.305	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	846	489	180	1200	1020	2

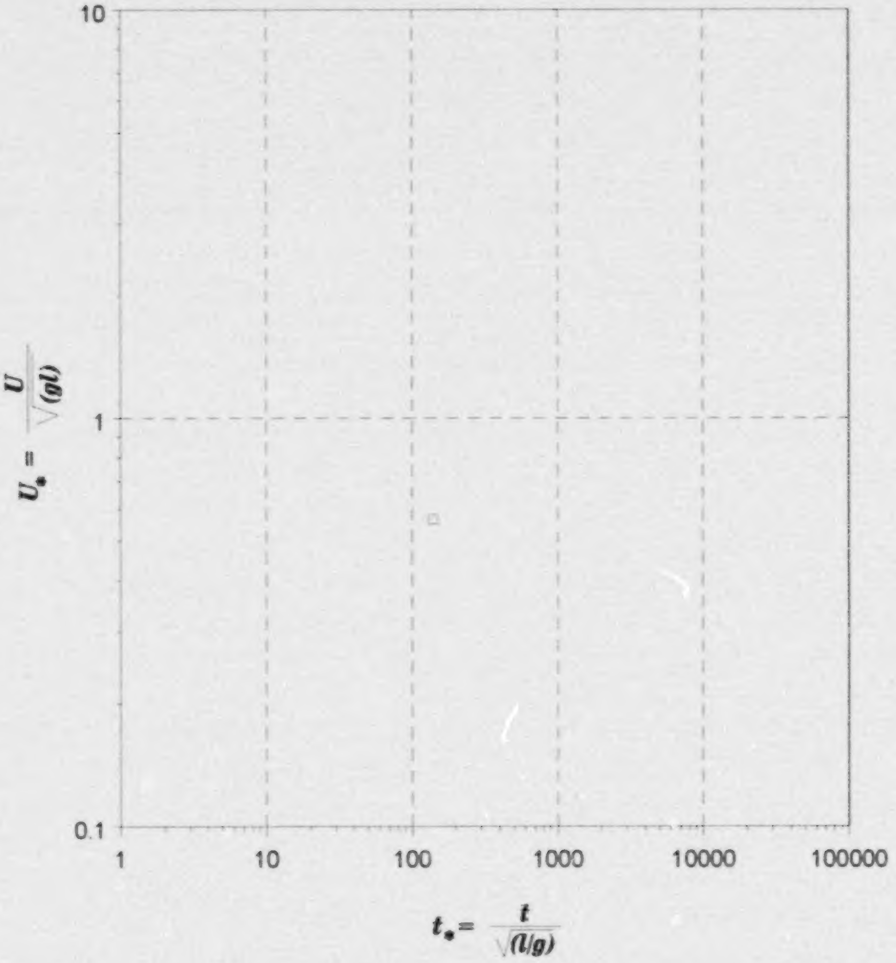


Figure C-096. Processed endurance data for Pimephales vigilax *(Bullhead Minnow): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Leavy and Bonner (2009).*

Table C-096. Data summary. Fish count 12, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.05	0	0.05	0.05	0	1
T (C)	23.4	0	23.4	23.4	0	1
U (m/s)	0.396	0	0.396	0.396	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

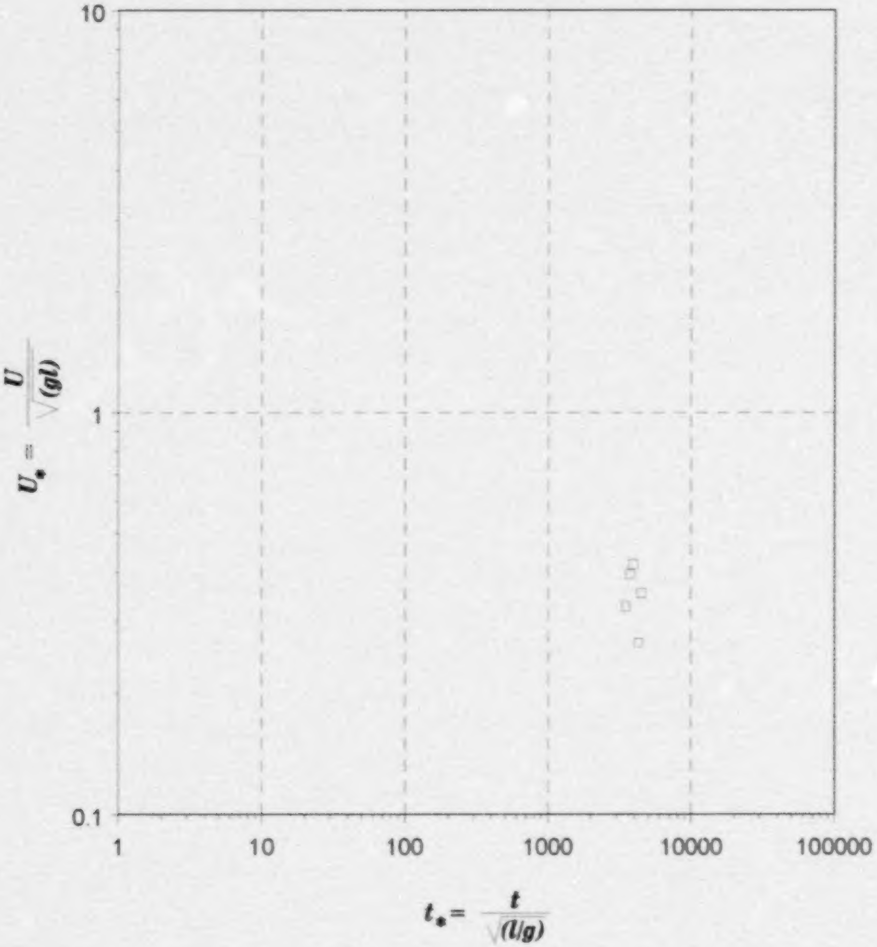


Figure C-097. Processed endurance data for Platygobio gracilus *(Flathead Chub): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973).*

Table C-097. Data summary. Fish count 26, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.233	0.038	0.175	0.288	0.113	5
T (C)	16	0	16	16	0	1
U (m/s)	0.556	0.091	0.367	0.625	0.258	5
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

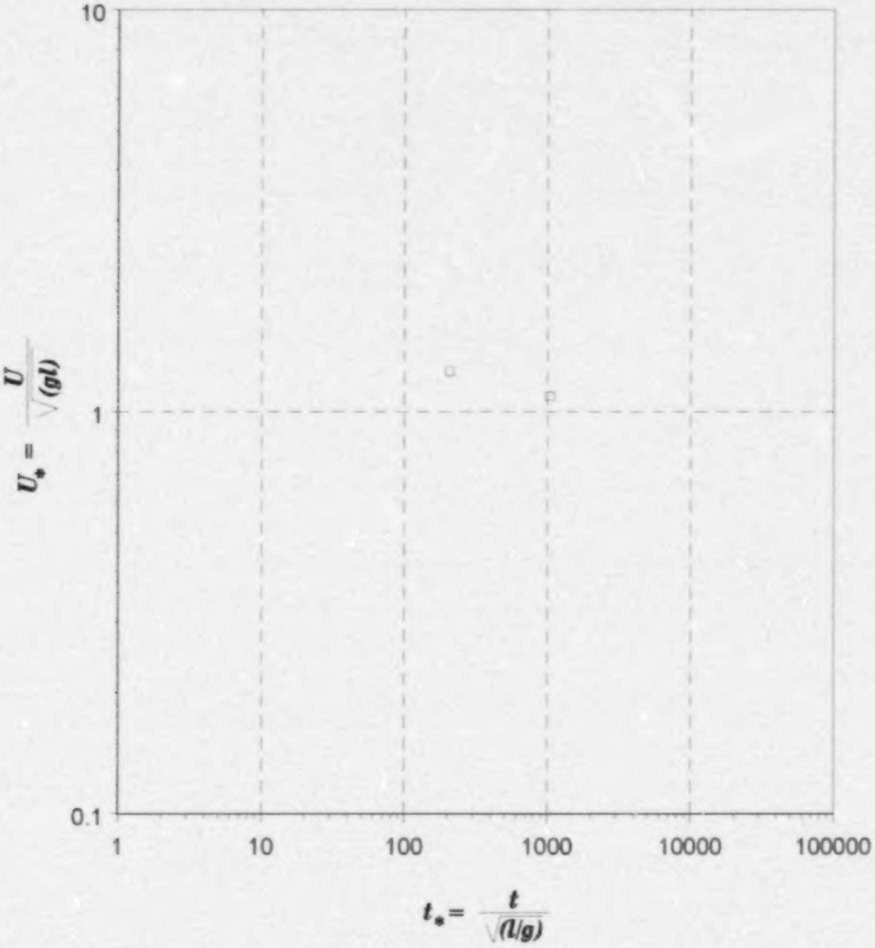


Figure C-098. Processed endurance data for Plecoglossus altivelis *(Ayu): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Tsukamoto et al. (1975).*

Table C-098. Data summary. Fish count 20, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.144	0	0.144	0.144	0	1
T (C)	18	0	18	18	0	1
U (m/s)	1.4	0.103	1.3	1.5	0.2	2
t_e (s)	76	52	25	126	101	2
$t_{\Delta t}$ (s)	.	.	.	.	.	0

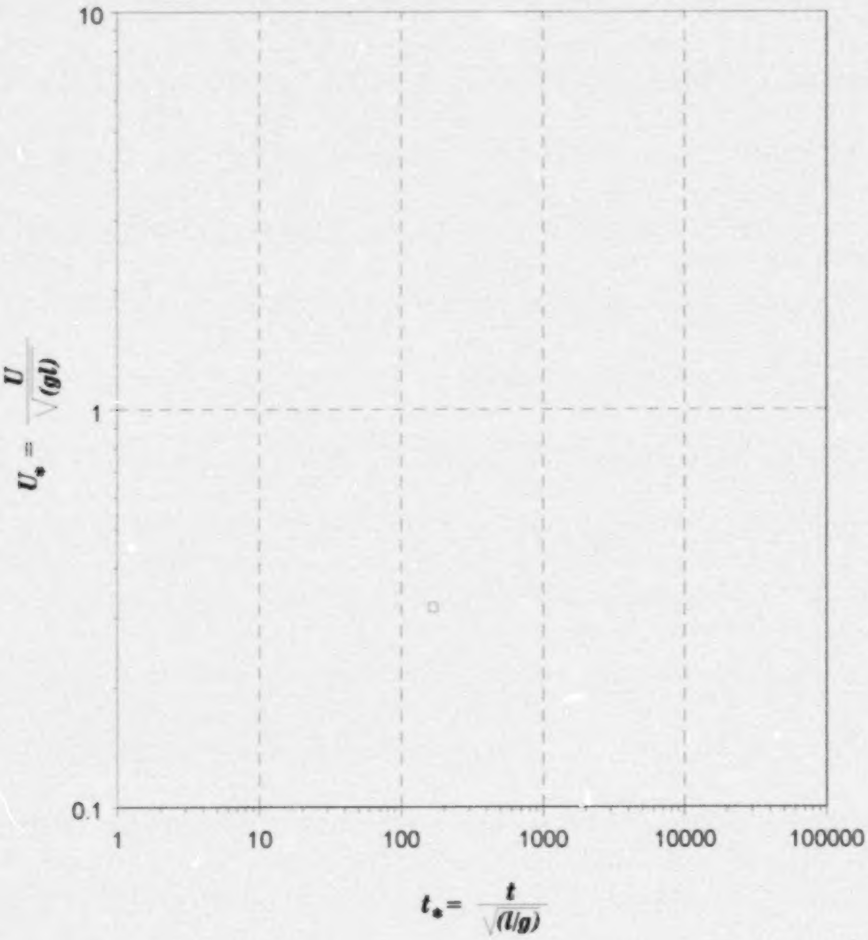


Figure C-099. Processed endurance data for Poecilia latipinna *(Sailfin Molly): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-099. Data summary. Fish count 5, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.035	0	0.035	0.035	0	1
T (C)	22.7	0	22.7	22.7	0	1
U (m/s)	0.186	0	0.186	0.186	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

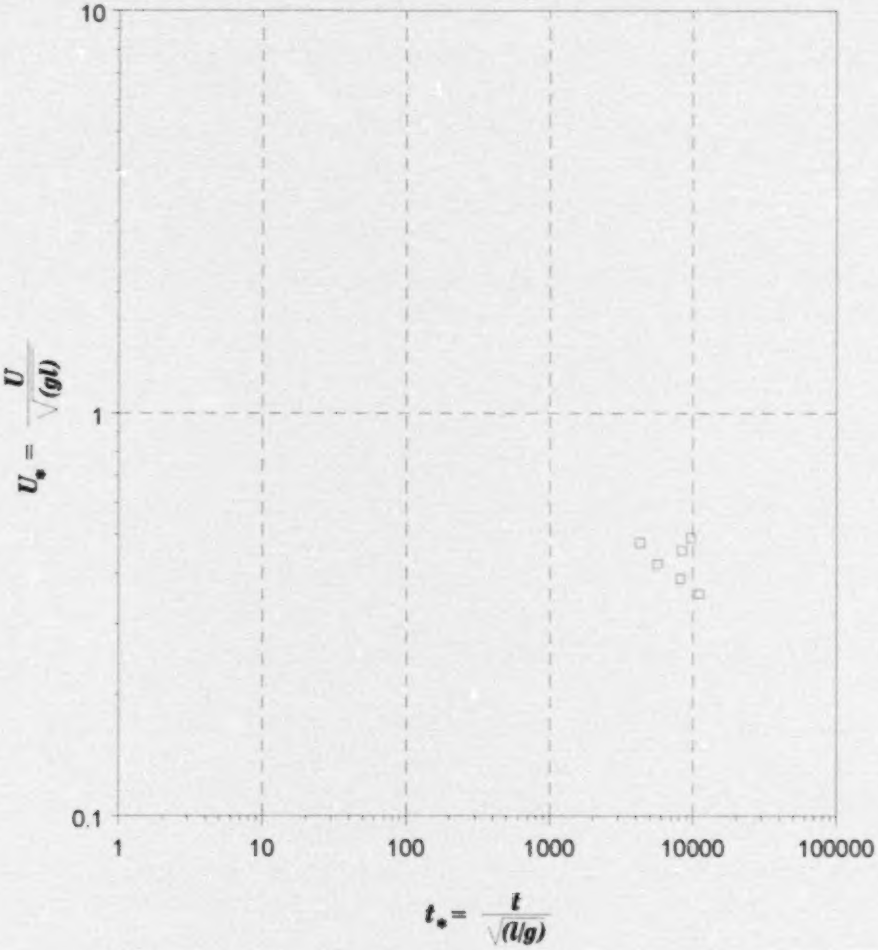


Figure C-100. Processed endurance data for Pogonichthys macrolepidotus *(Sacramento Splittail): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Cech and Young (1995).*

Table C-100. Data summary. Fish count 66, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.079	0.058	0.029	0.195	0.166	6
T (C)	18	1.4	17	20	3	2
U (m/s)	0.365	0.152	0.19	0.66	0.47	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

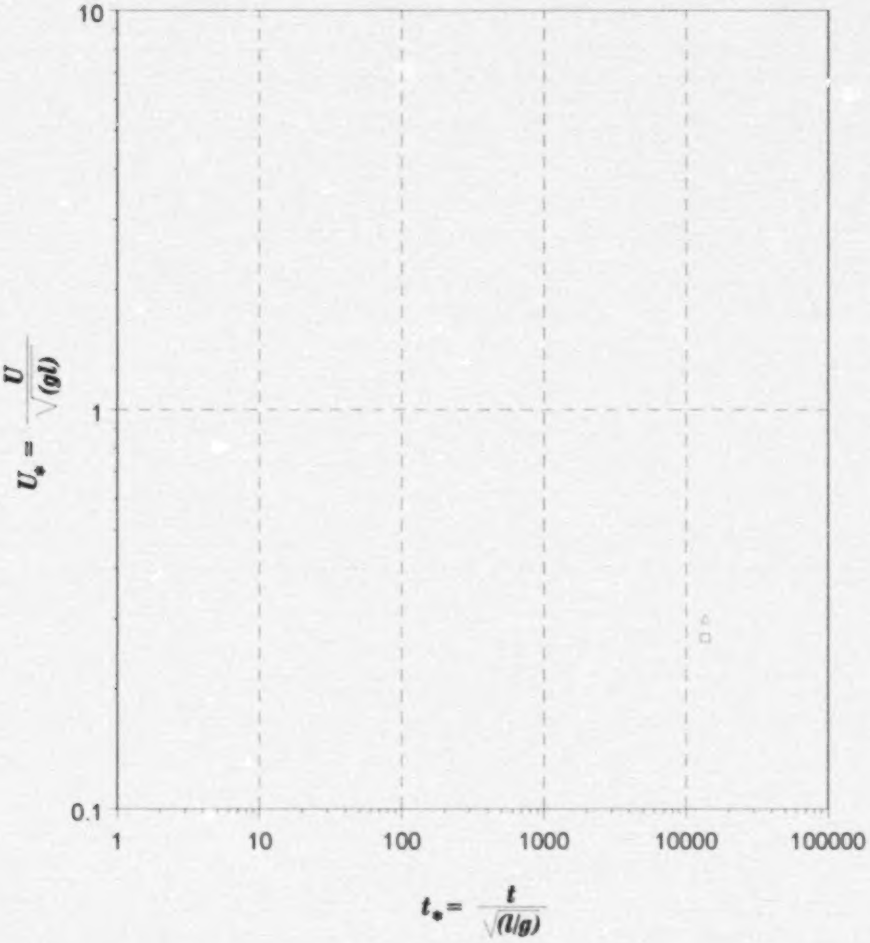


Figure C-101. Processed endurance data for Pomoxis annularis *(White Crappie): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Parsons and Sylvester (1992); red triangle is data from Parsons (1993).*

Table C-101. Data summary. Fish count 19, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.17	0	0.17	0.17	0	1
T (C)	25	0	25	25	0	1
U (m/s)	0.362	0.02	0.347	0.387	0.04	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

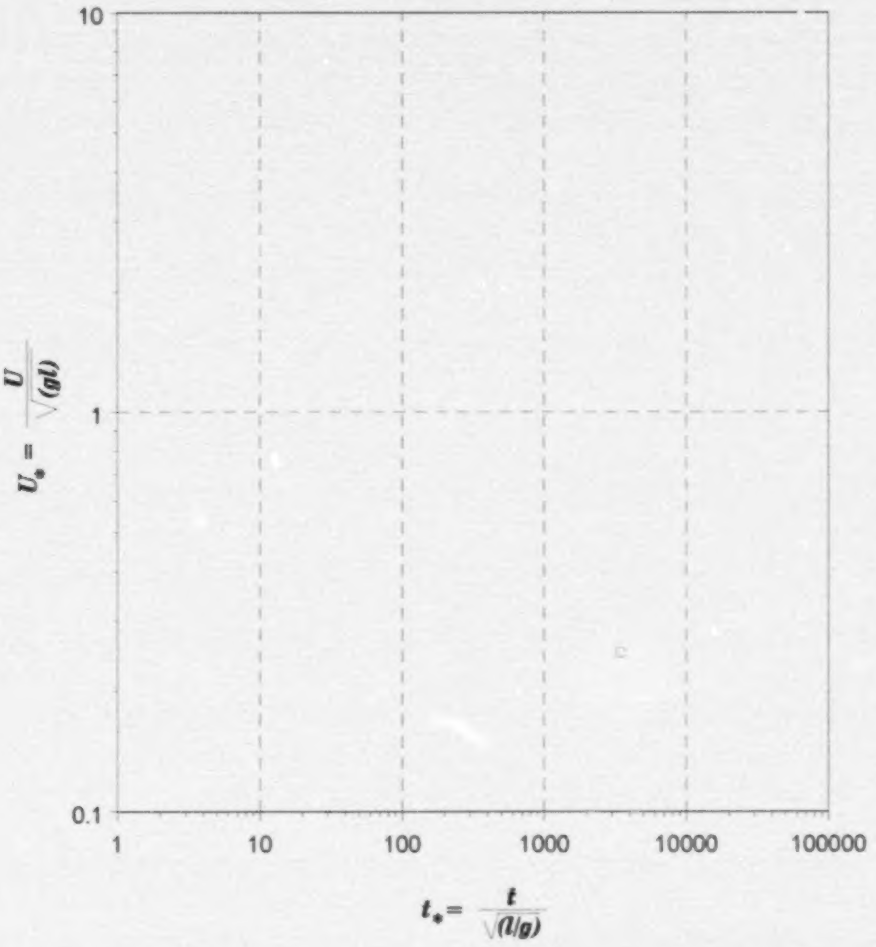


Figure C-102. Processed endurance data for Prosopium williamsoni *(Mountain Whitefish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue square is data from Jones et al. (1973).*

Table C-102. Data summary. Fish count 9, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.3	0	0.3	0.3	0	1
T (C)	10	0	10	10	0	1
U (m/s)	0.43	0	0.43	0.43	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

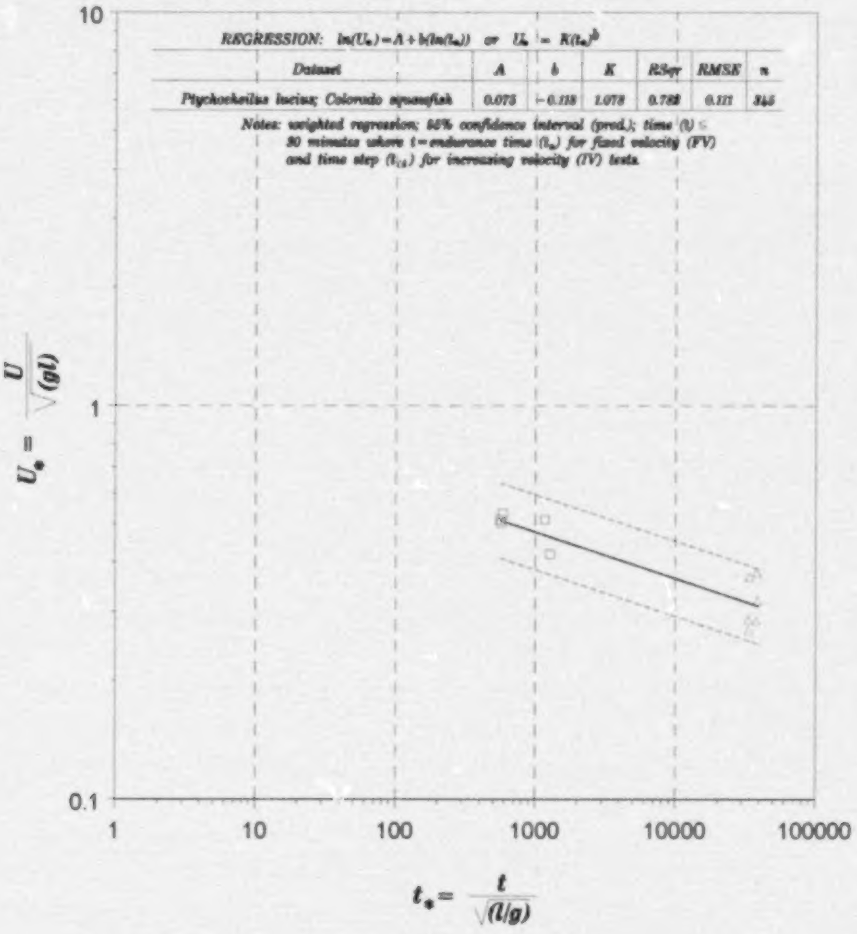


Figure C-103. Processed endurance data for Ptychocheilus lucius *(Colorado Squawfish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Berry and Pimentel (1985); red triangles are data from Childs and Clarkson (1996).*

Table C-103. Data summary. Fish count 345, record count 11.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.111	0.133	0.022	0.451	0.43	11
T (C)	17.4	5.6	10	26	16	4
U (m/s)	0.406	0.301	0.133	1.08	0.947	11
t_e (s)	870	836	120	1800	1680	2
$t_{\Delta t}$ (s)	.	.	.	.	.	0

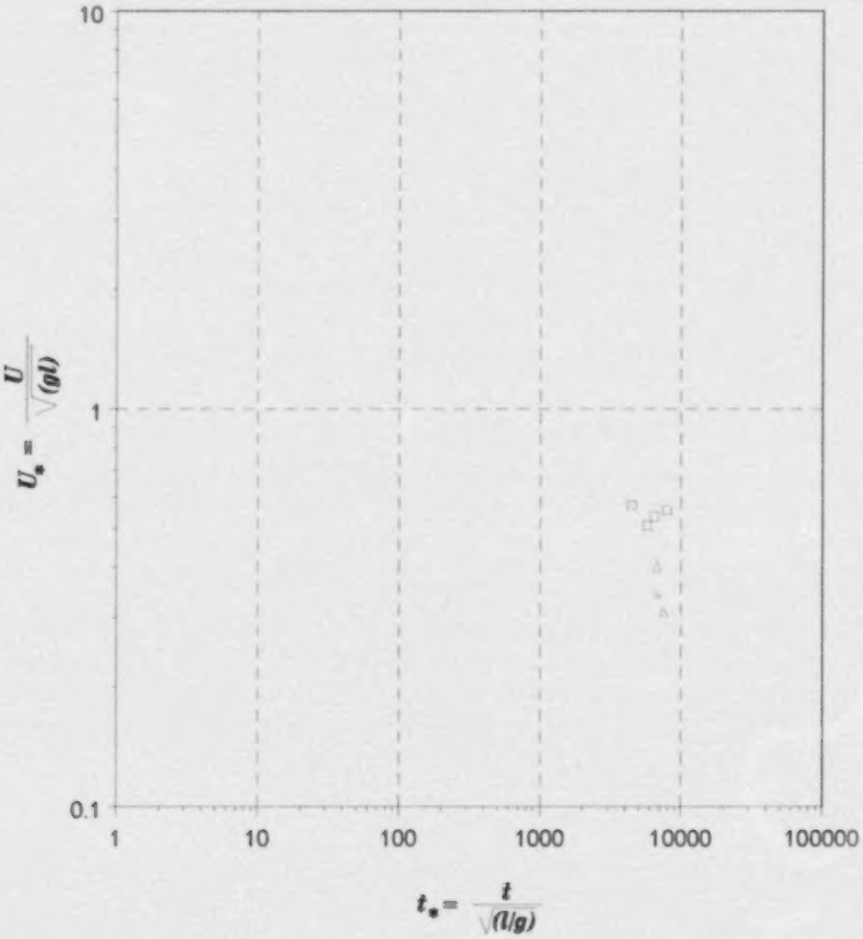


Figure C-104. Processed endurance data for Ptychocheilus oregonensis *(Northern Squawfish): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Mesa and Olson (1993); red triangles are data from Kolok and Farrell (1994a); green stars are data from Kolok and Farrell (1994b).*

Table C-104. Data summary. Fish count 106, record count 7.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.35	0.061	0.25	0.435	0.185	5
T (C)	14.5	3.8	5	18	13	4
U (m/s)	0.856	0.249	0.484	1.15	0.666	7
t_e (s)	1242	299	846	1662	816	4
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

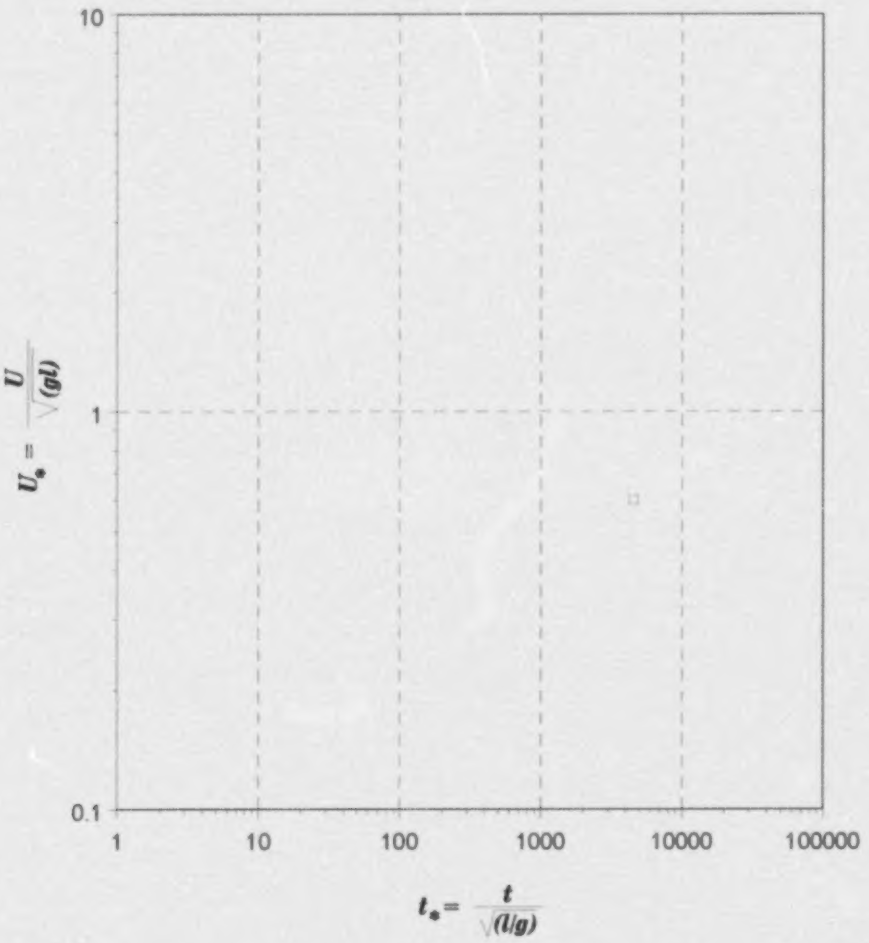


Figure C-105. Processed endurance data for Rhinichthys atratulus *(Blacknose Dace): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Nelson et al. (2003).*

Table C-105. Data summary. Fish count 32, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.043	0	0.043	0.043	0	1
T (C)	24	0	24	24	0	1
U (m/s)	0.387	0	0.387	0.387	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

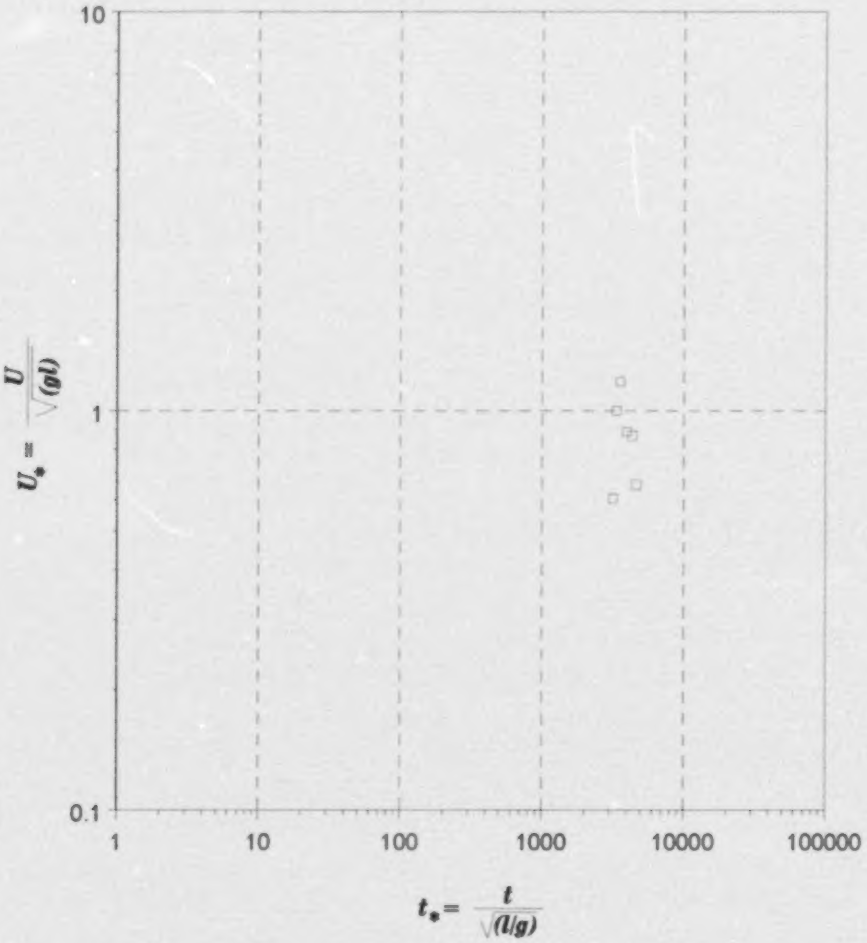


Figure C-106. Processed endurance data for Rhinichthys cataractae *(Longnose Dace): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Aedo et al. (2009).*

Table C-106. Data summary. Fish count 15, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.066	0.016	0.041	0.087	0.046	6
T (C)	17	0	17	17	0	1
U (m/s)	0.727	0.205	0.415	0.982	0.567	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

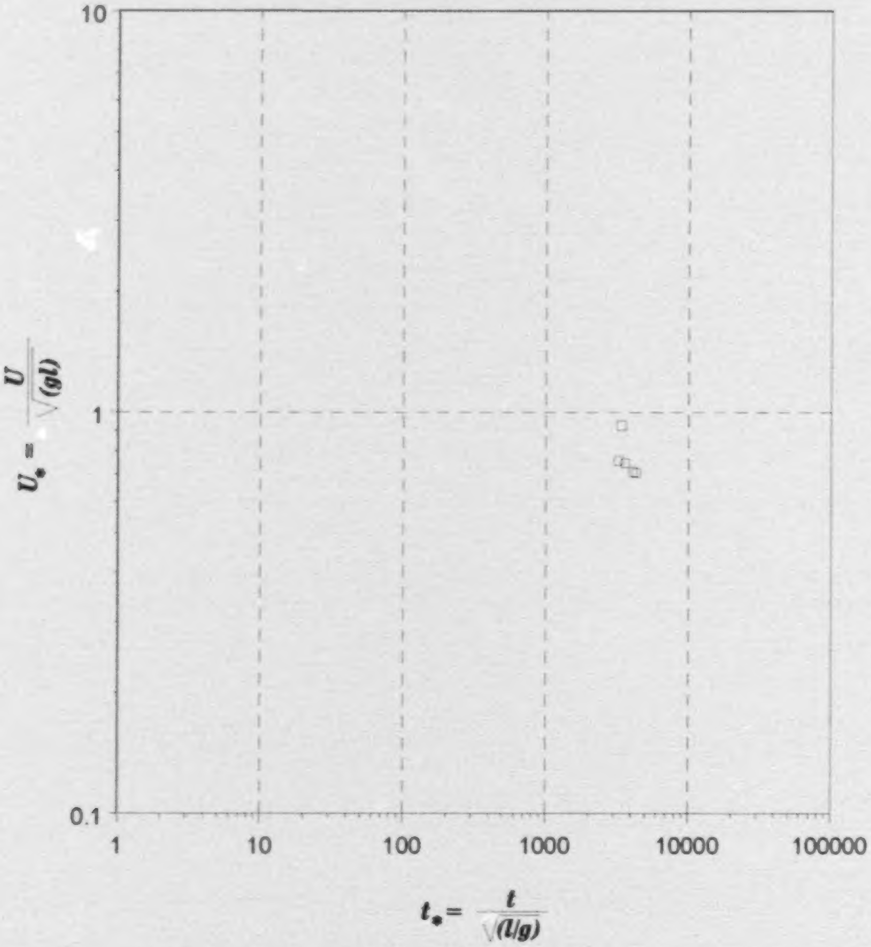


Figure C-107. Processed endurance data for Rhinichthys osculus *(Speckled Dace): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Aedo et al. (2009).*

Table C-107. Data summary. Fish count 20, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.071	0.011	0.048	0.085	0.037	5
T (C)	17	0	17	17	0	1
U (m/s)	0.694	0.127	0.485	0.806	0.321	5
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

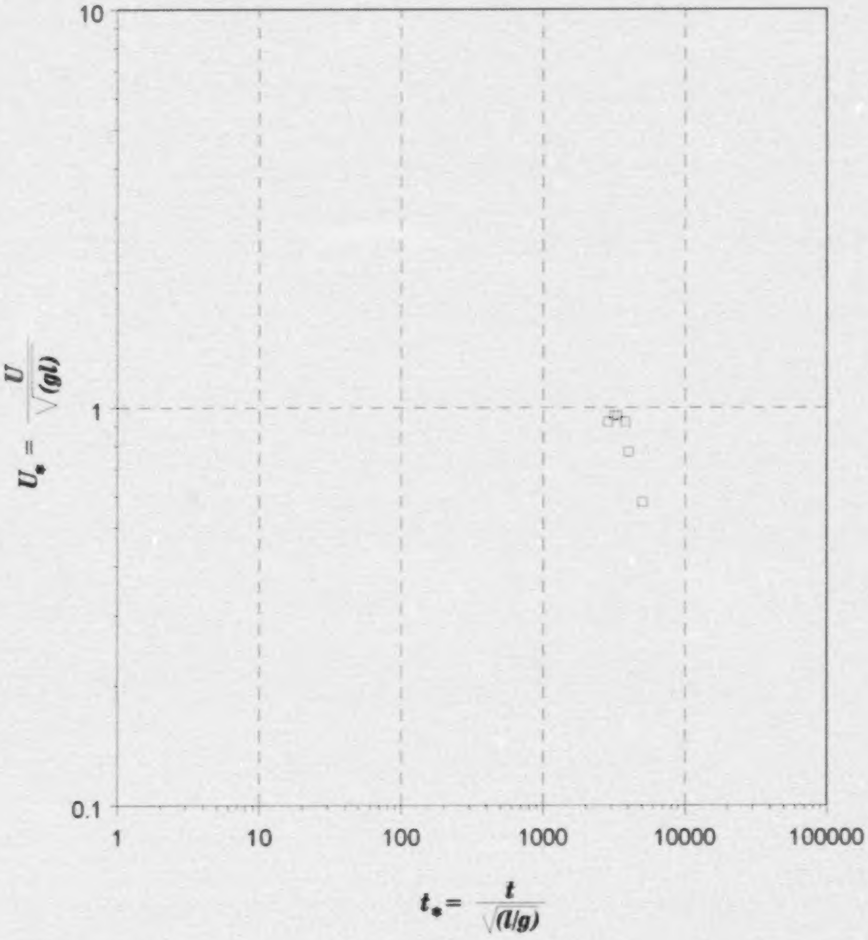


Figure C-108. Processed endurance data for Richardsonius balteatus *(Redside Shiner): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Aedo et al. (2009).*

Table C-108. Data summary. Fish count 18, record count 6.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.074	0.022	0.035	0.108	0.073	6
T (C)	17	0	17	17	0	1
U (m/s)	0.755	0.192	0.339	0.947	0.608	6
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	300	0	300	300	0	1

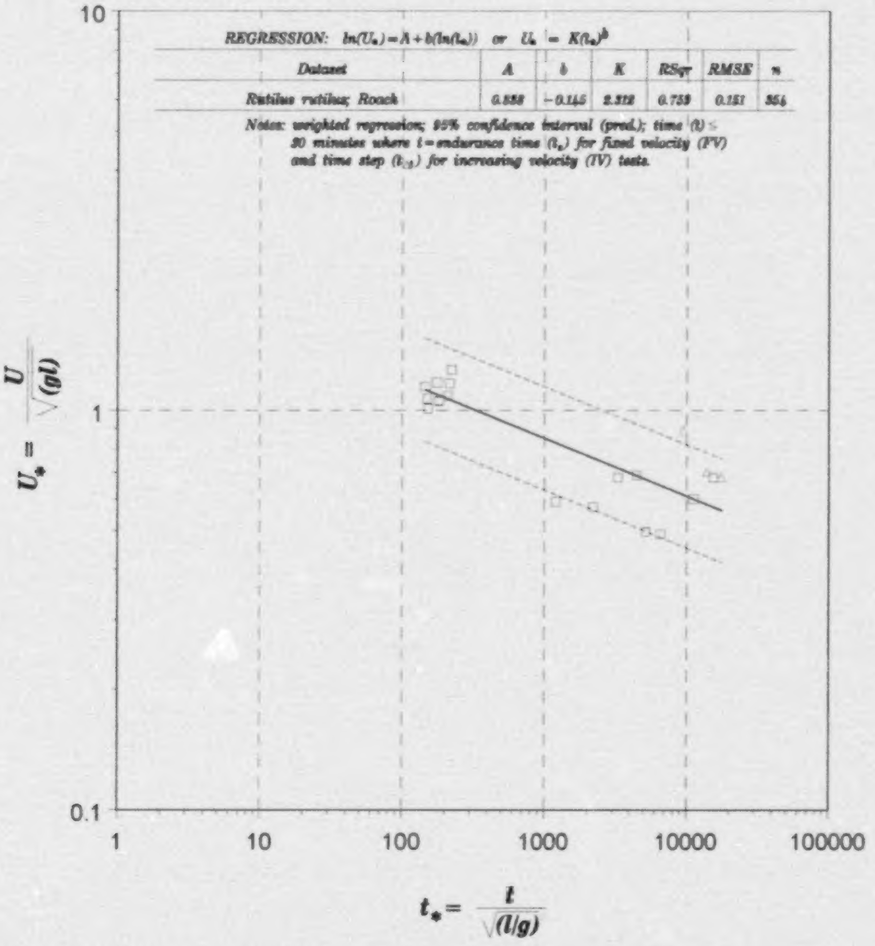


Figure C-109. Processed endurance data for Rutilus rutilus (Roach): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Clough and Tumpenny (2000); red triangles are data from Tudoraache et al. (2008).*

Table C-109. Data summary. Fish count 354, record count 20.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.13	0.038	0.046	0.186	0.14	17
T (C)	14.2	3.4	8.8	18.5	9.7	16
U (m/s)	1.017	0.3	0.458	1.552	1.094	14
t_e (s)	867	527	156	1733	1577	8
$t_{\Delta t}$ (s)	141	359	20	1200	1180	2

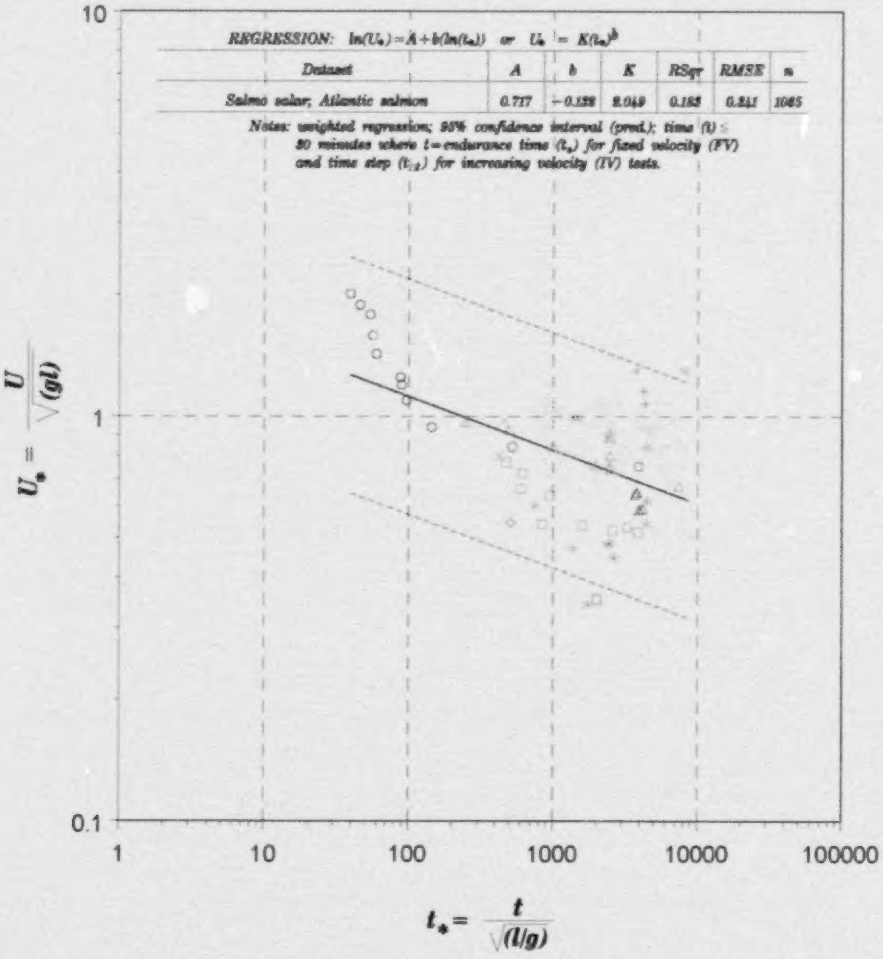


Figure C-110. Processed endurance data for Salmo salar (Atlantic Salmon): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from McCleave and Stred (1975); red triangles are data from Booth et al. (1997b); green stars are data from Booth et al. (1997a); black circles are data from Colavecchia (1997); turquoise diamonds are data from Peake et al. (1997b); blue crosses are data from Peake et al. (1997c); red x's are data from Thorstad et al. (1997); green squares are data from McDonald et al.(1998), black triangles are data from McDonald et al.(1998); turquoise stars are data from Beddow and Mckinley (1999); blue circles are data from Thorstad et al. (2000); red diamonds are data from Enders et al. (2008).*

Table C-110. Data summary. Fish count 1065, record count 145.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.213	0.173	0.048	0.615	0.567	104
T (C)	13.1	3.5	4	20.5	16.5	55
U (m/s)	1.199	0.842	0.38	4.49	4.11	128
t_e (s)	164	224	7	1800	1793	44
$t_{\Delta t}$ (s)	430	187	120	600	480	3

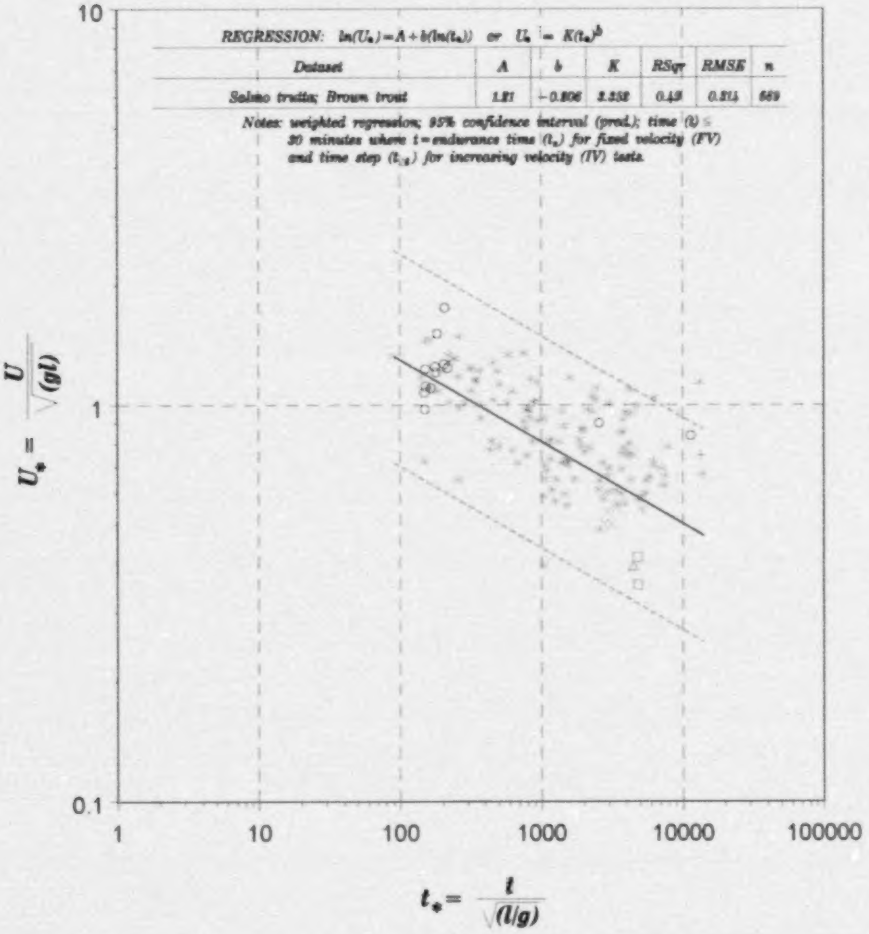


Figure C-111. Processed endurance data for Salmo trutta (Brown Trout): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Butler et al. (1992); red triangles are data from Beaumont et al. (1995a); green stars are data from Peake et al. (1997b); black circles are data from Clough and Tumpenny (2000); turquoise diamonds are data from Ojanguran and Brana (2003); blue crosses are data from Tudorache et al. (2008); red x's are data from Aedo et al. (2009).*

Table C-111. Data summary. Fish count 669, record count 160.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.153	0.076	0.048	0.4	0.352	132
T (C)	11.4	4.8	5	21.2	16.2	17
U (m/s)	1.085	0.431	0.316	1.788	1.472	95
t_e (s)	315	441	11	1652	1641	69
$t_{\Delta t}$ (s)	245	326	20	1200	1180	6

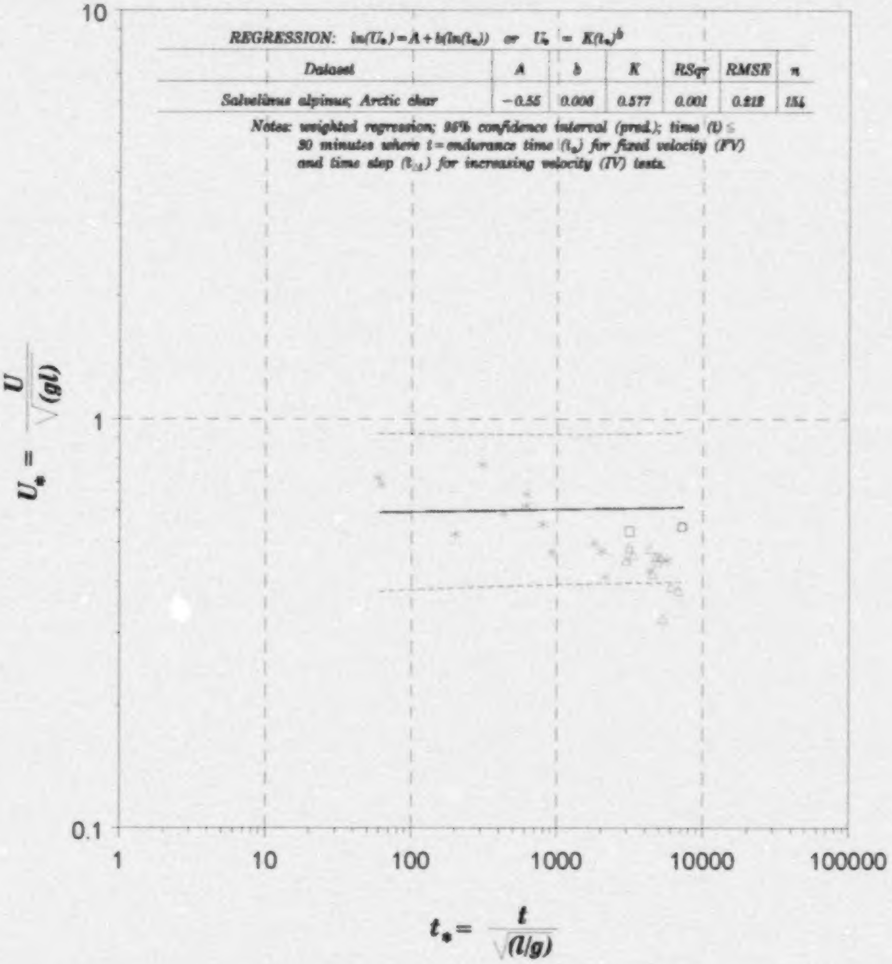


Figure C-112. Processed endurance data for Salvelinus alpinus (Arctic Char): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue square is data from Jones et al. (1973); red triangles are data from Welch (1979); green stars are data from Beamish (1980); black circles are data from Hunter and Scherer (1988); turquoise diamonds are data from Jones and Moffitt (2004).*

Table C-112. Data summary. Fish count 154, record count 30.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.227	0.084	0.077	0.401	0.324	28
T (C)	11.1	2.4	9	15	6	4
U (m/s)	0.901	0.187	0.33	1.3	0.97	17
t_e (s)	616	286	11	1028	1017	17
$t_{\Delta t}$ (s)	664	124	600	900	300	2

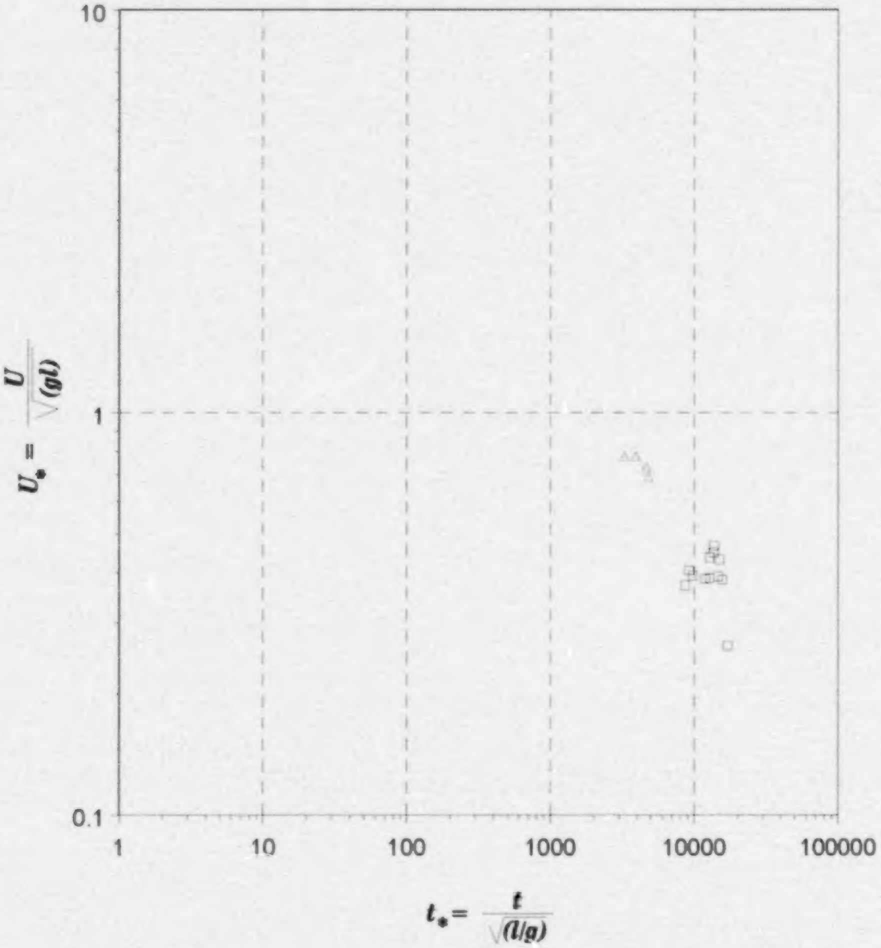


Figure C-113. Processed endurance data for Salvelinus confluentus (Bull Trout): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Mesa et al. (2003b); red triangles are data from Jones and Moffitt (2004).*

Table C-113. Data summary. Fish count 106, record count 16.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.207	0.046	0.109	0.425	0.316	15
T (C)	12.3	2.9	9	15	6	3
U (m/s)	0.977	0.193	0.272	1.15	0.878	15
t_e (s)	598	60	494	647	153	4
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

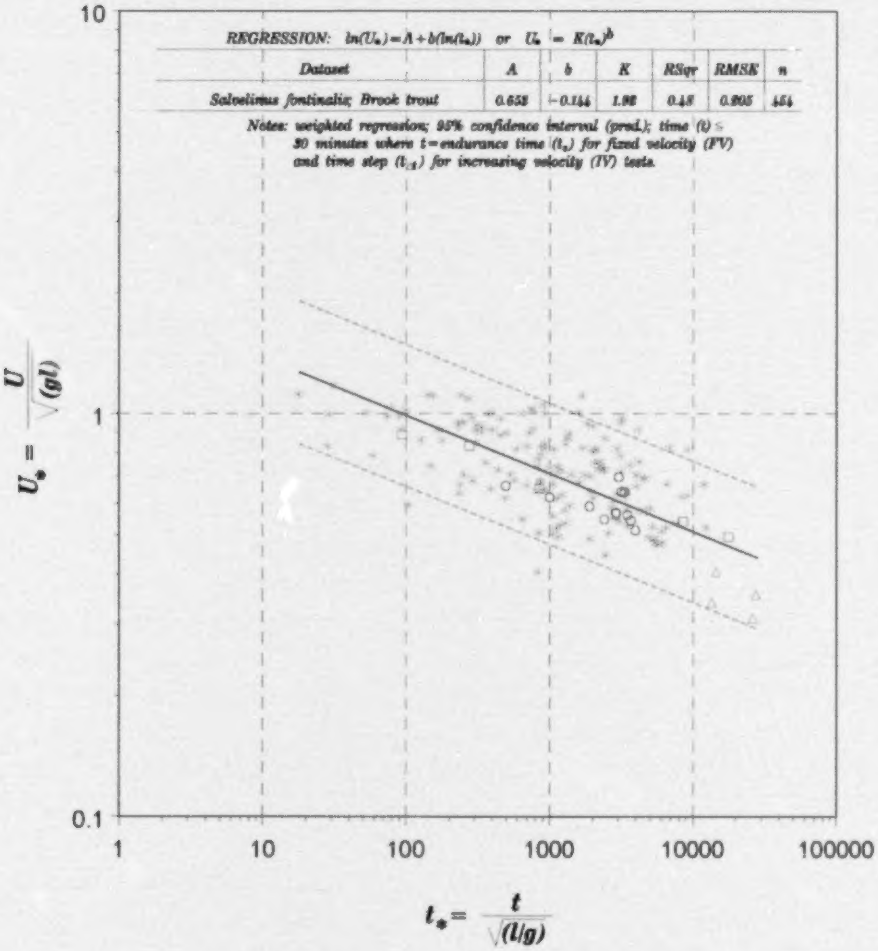


Figure C-114. Processed endurance data for Salvelinus fontinalis (Brook Trout): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Peterson (1974); red triangles are data from Beamish (1980); green stars are data from Peake et al. (1997b); black circles are data from McDonald et al. (1998); turquoise diamonds are from Paul et al. (2005).*

Table C-114. Data summary. Fish count 454, record count 177.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.129	0.063	0.039	0.405	0.367	147
T (C)	15.9	2.9	9.5	20	10.5	36
U (m/s)	0.755	0.348	0.21	1.843	1.633	117
t_e (s)	261	324	2	1537	1535	79
$t_{\Delta t}$ (s)	612	605	10	1800	1790	8

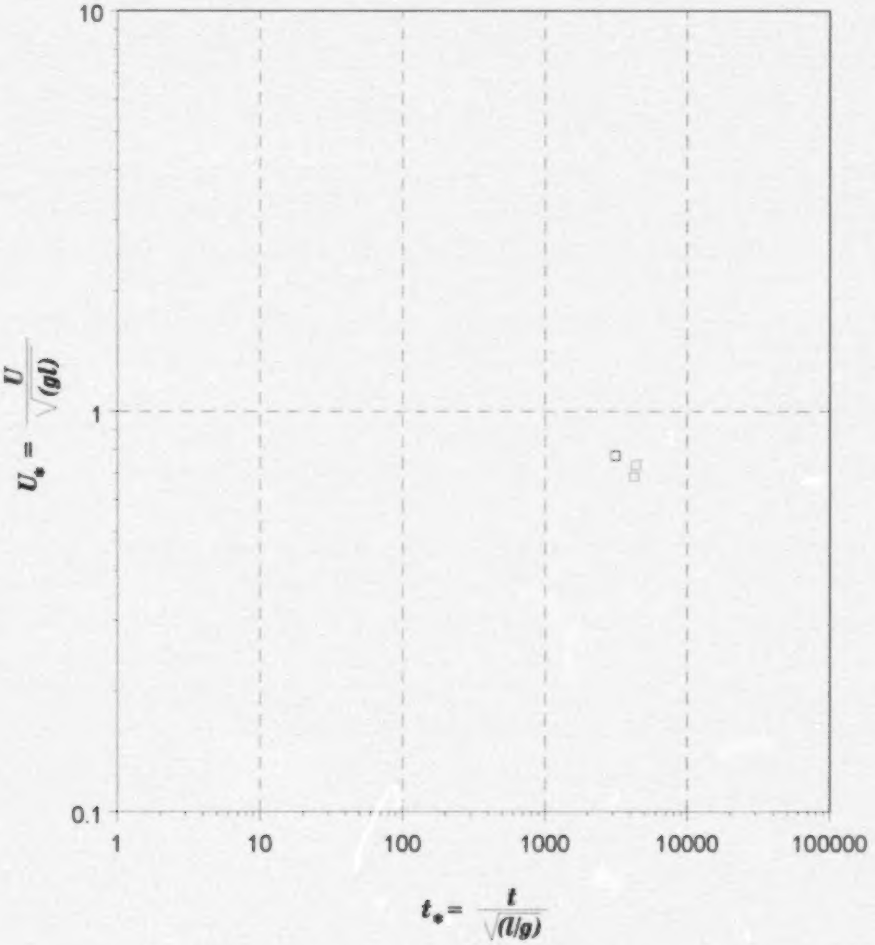


Figure C-115. Processed endurance data for Salvelinus namaycush (Lake Trout): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones and Moffitt (2004).*

Table C-115. Data summary. Fish count 90, record count 4.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.202	0.021	0.175	0.225	0.05	4
T (C)	12.3	3	9	15	6	2
U (m/s)	1.044	0.102	0.9	1.15	0.25	3
t_e (s)	538	58	473	603	130	4
$t_{\Delta t}$ (s)	.	.	.	.	.	0

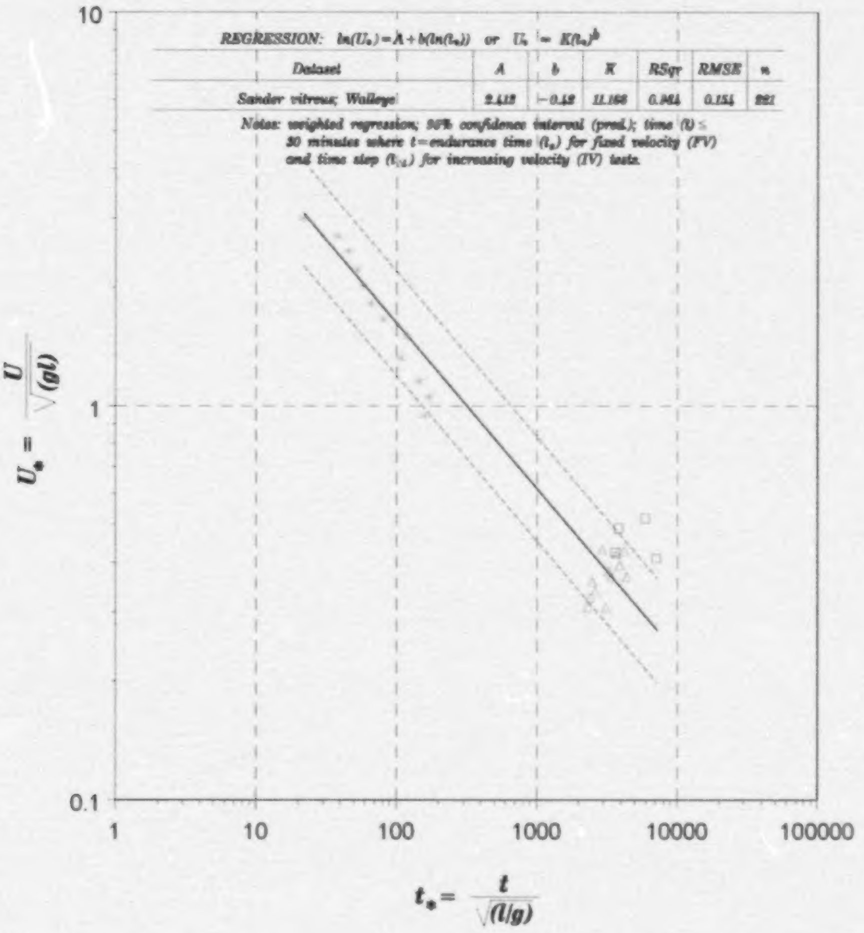


Figure C-116. Processed endurance data for Sander vitreus (Walleye): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973); red triangles are data from Peake et al. (2000); green stars are Castro-Santos (2005).*

Table C-116. Data summary. Fish count 221, record count 28.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.339	01	0.07	0.665	0.595	17
T (C)	13.8	1.7	12.7	20	7.3	3
U (m/s)	2.601	1.558	0.34	5.292	4.952	28
t_e (s)	13	7	4	31	27	12
$t_{\Delta t}$ (s)	600	0	600	600	0	1

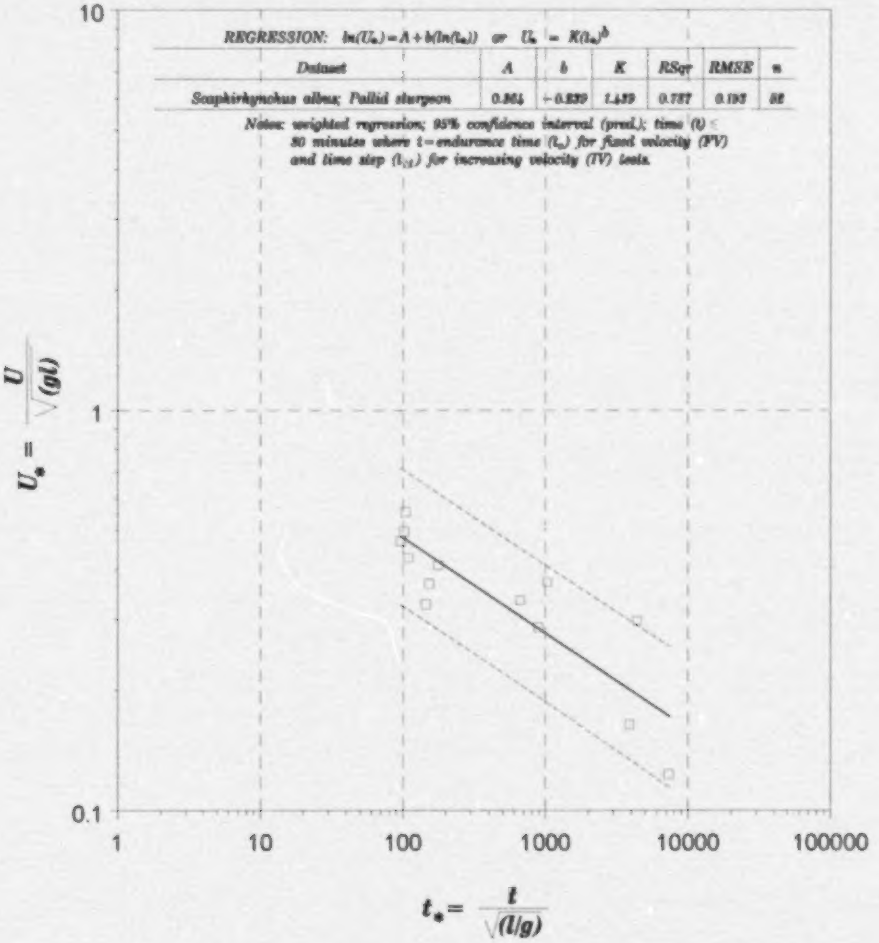


Figure C-117. Processed endurance data for Scaphirhynchus albus (Pallid Sturgeon): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Adams et al. (1999).*

Table C-117. Data summary. Fish count 52, record count 13.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.166	0.016	0.152	0.184	0.032	2
T (C)	18.5	0	18.5	18.5	0	1
U (m/s)	0.492	0.161	0.15	0.68	0.53	9
t_e (s)	154	258	12	912	900	13
$t_{\Delta t}$ (s)	.	.	.	.	.	0

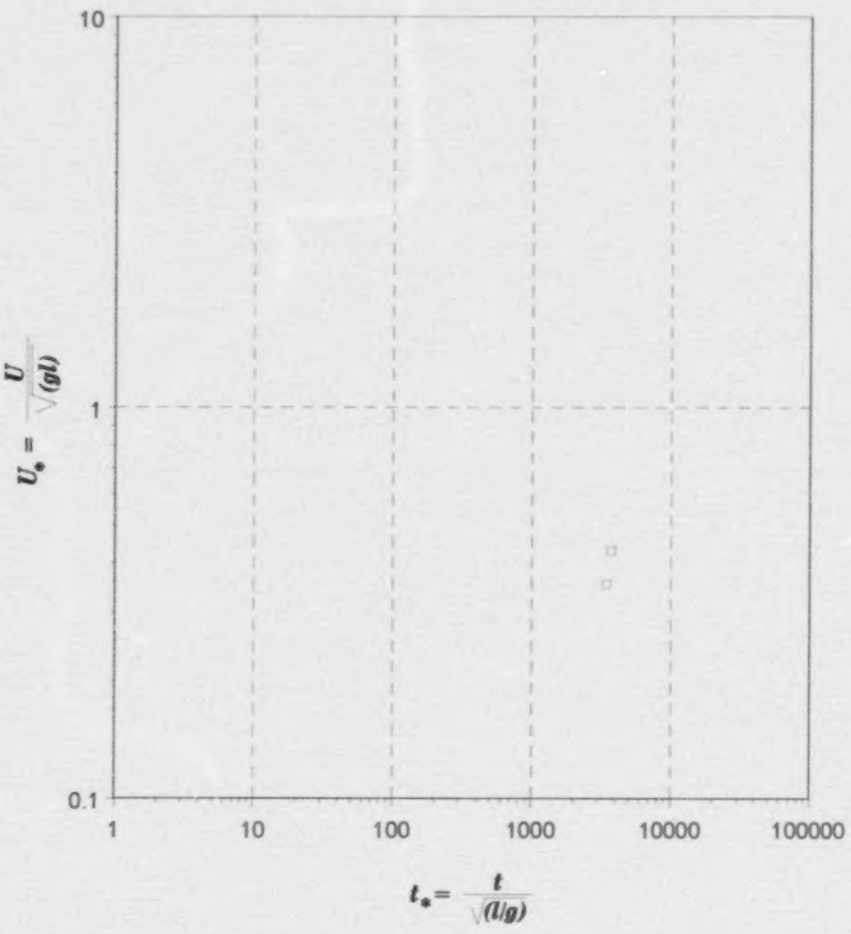


Figure C-118. Processed endurance data for Scaphirhynchus platorynchus *(Shovelnose Sturgeon): dimensionless swim speed (U*) versus dimensionless time-to-fatigue (t*). Blue squares are data from Adams et al. (1997).*

Table C-118. Data summary. Fish count 5, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.631	0.056	0.57	0.672	0.102	2
T (C)	16	0	16	16	0	1
U (m/s)	0.953	0.061	0.909	1.02	0.111	2
t_e (s)	-	-	-	-	-	0
$t_{\Delta t}$ (s)	900	0	900	900	0	1

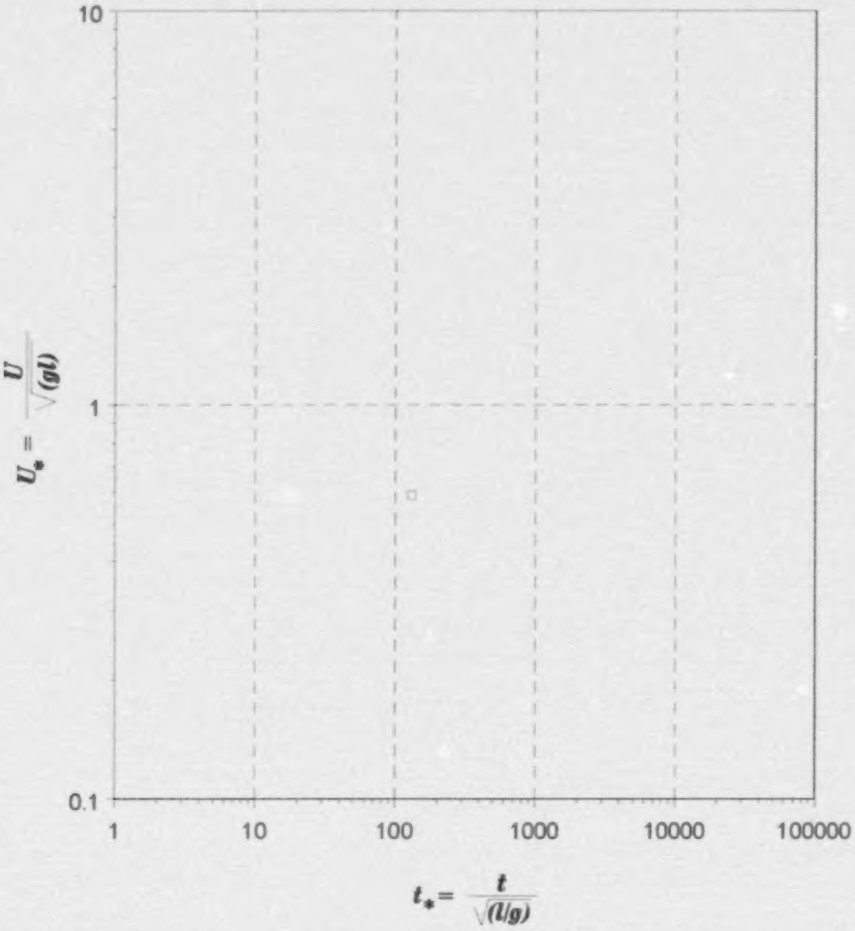


Figure C-119. Processed endurance data for Semotilus atromaculatus (Creek Chub): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue square is data from Leavy and Bonner (2009).*

Table C-119. Data summary. Fish count 9, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.057	0	0.057	0.057	0	1
T (C)	28.5	0	28.5	28.5	0	1
U (m/s)	0.442	0	0.442	0.442	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

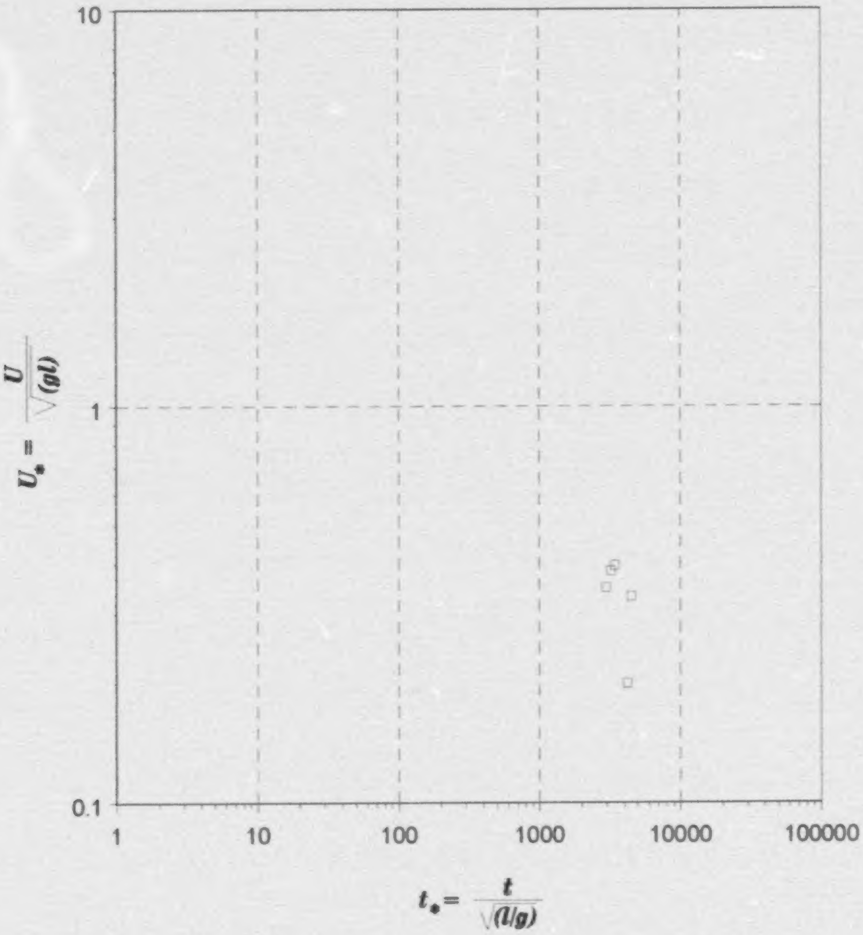


Figure C-120. Processed endurance data for Stenodus leucichthys (Inconnu): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973).*

Table C-120. Data summary. Fish count 19, record count 5.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.296	0.089	0.174	0.403	0.229	5
T (C)	16	0	16	16	0	1
U (m/s)	0.603	0.141	0.28	0.703	0.423	5
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

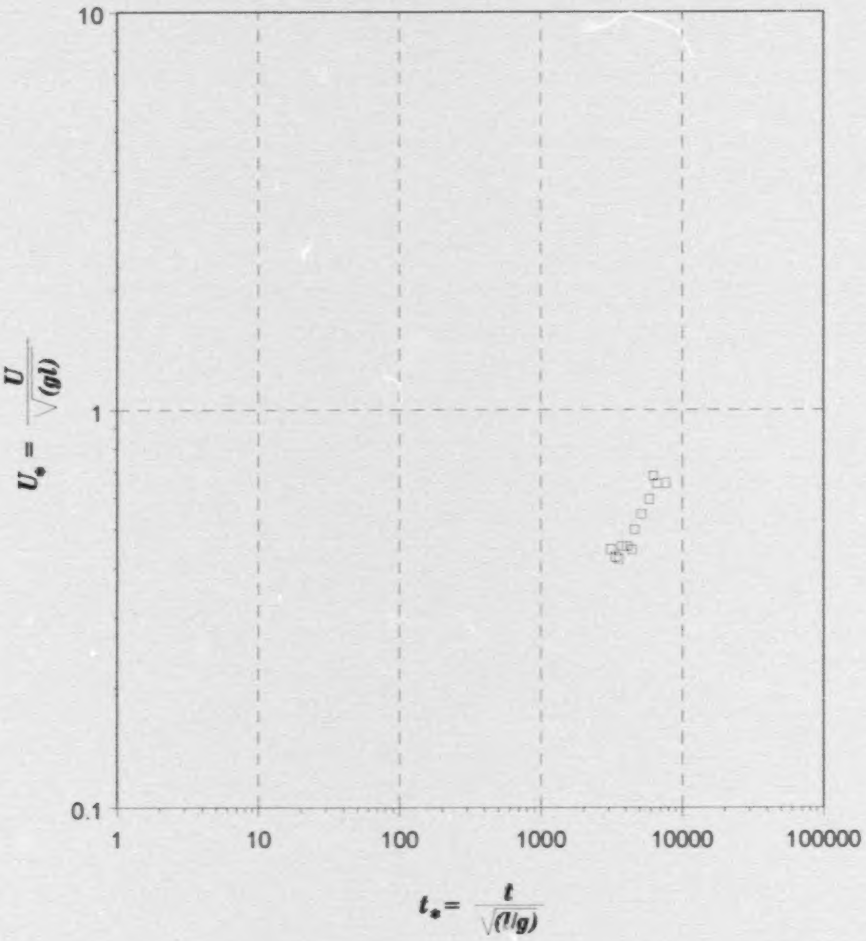


Figure C-121. Processed endurance data for Thymallus arcticus (Arctic Grayling): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Jones et al. (1973).*

Table C-121. Data summary. Fish count 89, record count 12.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.227	0.071	0.06	0.36	0.3	12
T (C)	16	0	16	16	0	1
U (m/s)	0.673	0.058	0.5	0.835	0.335	12
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

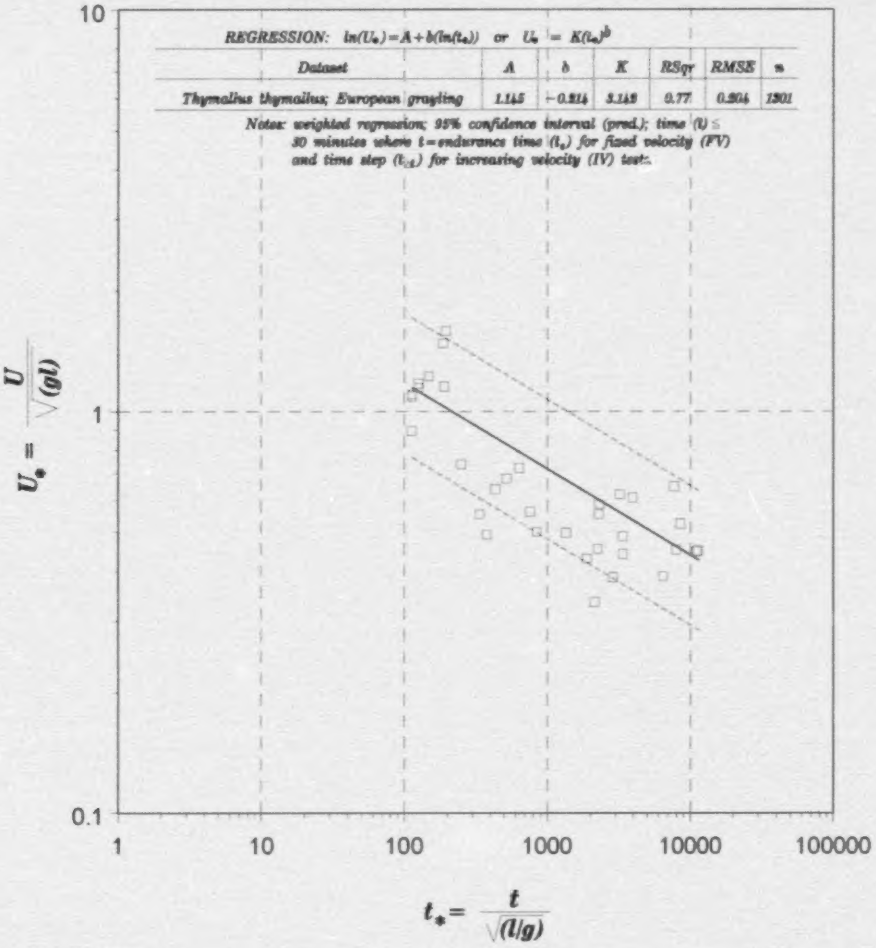


Figure C-122. Processed endurance data for Thymallus thymallus (European Grayling): dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are data from Clough et al. (2003).*

Table C-122. Data summary. Fish count 1301, record count 34.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.166	0.083	0.082	0.312	0.23	31
T (C)	13.1	4	5.8	20.9	15.1	25
U (m/s)	0.946	0.525	0.37	1.907	1.537	16
t_e (s)	610	450	30	1440	1410	16
$t_{\Delta t}$ (s)	20	0	20	20	0	1

APPENDIX 1–SERIES D

Processed Endurance Data

Dimensionless Swim Speed (U_*) vs Dimensionless Time-to-Fatigue (t_*)

Plotted by Taxonomic Classification (26 graphs)

- Taxonomic Classification – graphs showing separation based on taxonomic groupings of species – different taxonomic levels were tested including; order; family; genera; and species.

- Details on taxonomic groupings are contained in the report. Limited data at the species level prevented the creation of effective relationships for many species. Grouping at higher taxonomic levels showed reasonable relationships. Grouping at the order level was effective for most species with the exception of Perciformes where the data showed a poorer fit compared to other orders. Perciformes are the largest order of vertebrate and include 40% of all fish species (10,000 species; 160 families). They include a more diverse mix of morphologies which may explain the weaker relationships in the Perciformes group. Grouping based on taxonomic family was found to be more effective in terms of similarities in swimming performance.

- Swimming mode (see graphs in Appendix 1 – Series E) and taxonomic family were used in conjunction with data fit to combine species data that showed similarity in performance and arrive at the six species groups.

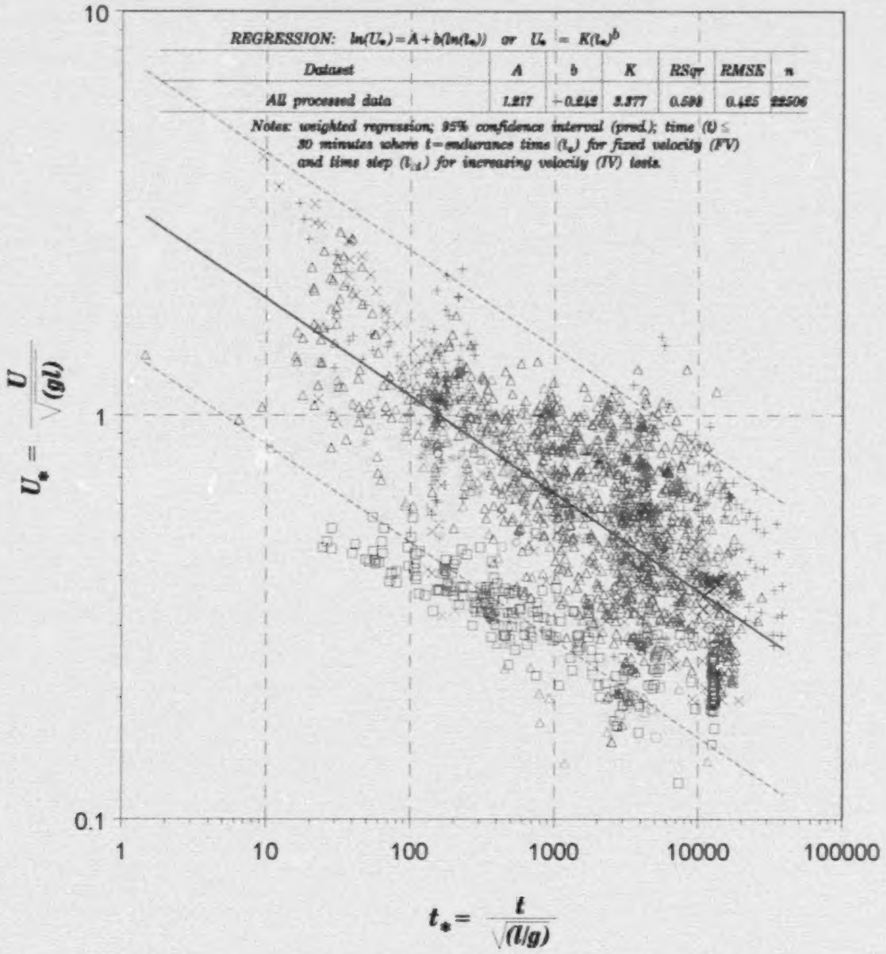


Figure D-1a. Processed endurance data: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Acipenseriformes; red triangles are Anguilliformes; green stars are Atheriniformes; black circles are Characiformes; turquoise diamonds are Clupeiformes; blue crosses are Cypriniformes; red x's are Cyprinodontiformes; green squares are Esociformes; black triangles are Gadiformes; turquoise stars are Gasterosteiformes; blue circles are Lepisosteiformes; red diamonds are Osmeriformes; green crosses are Osteoglossiformes; black x's are Perciformes; turquoise squares are Petromyzontiformes; blue triangles are Salmoniformes; red stars are Siluriformes.

Table D-1a. Data summary. Fish count 22506, record count 2045.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.209	0.187	0.021	1.32	1.299	724
T (C)	14.3	5.3	3.1	34	30.9	233
U (m/s)	1.161	1.26	0.11	9.45	9.34	997
t_e (s)	376	517	0	1800	1800	589
$t_{\Delta t}$ (s)	588	567	10	1800	1790	12

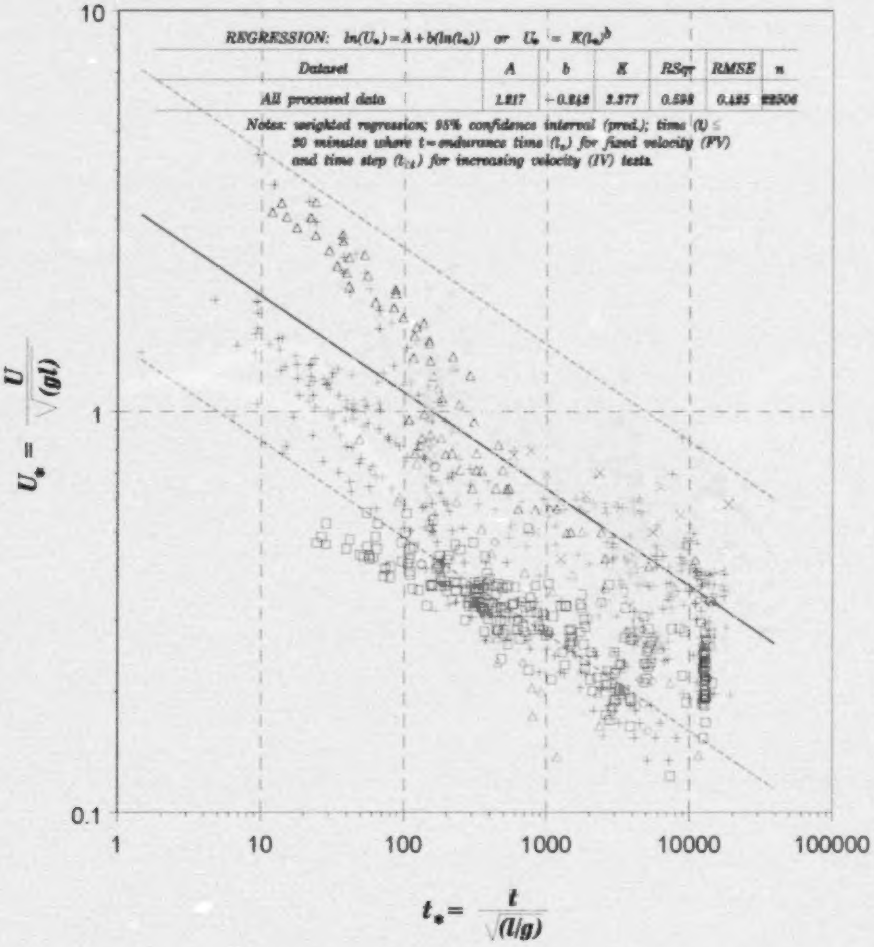


Figure D-1b. Processed data: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Acipenseridae; red triangles are Anguillidae; green stars are Atherinidae; black circles are Balitoridae; turquoise diamonds are Catostomidae; blue crosses are Centrarchidae; red x's are Characidae; green squares are Cichlidae; black triangles are Clupeidae; turquoise stars are Cyprinidae; blue circles are Cyprinodontidae; red diamonds are Esocidae; green crosses are Gadidae; black x's are Gasterosteidae; turquoise squares are Hiodontidae; blue triangles are Ictaluridae, and red stars are Lepisosteidae; black crosses are Moronidae; red crosses are Osmeridae; green crosses are Percidae; blue crosses are Petromyzontidae; turquoise crosses are Plecoglossidae, fuschia crosses are Poeciliidae; yellow crosses are Salmonidae.

Table D-1b. Data summary. Fish count 22506, record count 2045.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.209	0.187	0.021	1.32	1.299	724
T (C)	14.3	5.3	3.1	34	30.9	233
U (m/s)	1.161	1.26	0.11	9.45	9.34	997
t_e (s)	376	517	0	1800	1800	589
$t_{\Delta t}$ (s)	588	567	10	1800	1790	12

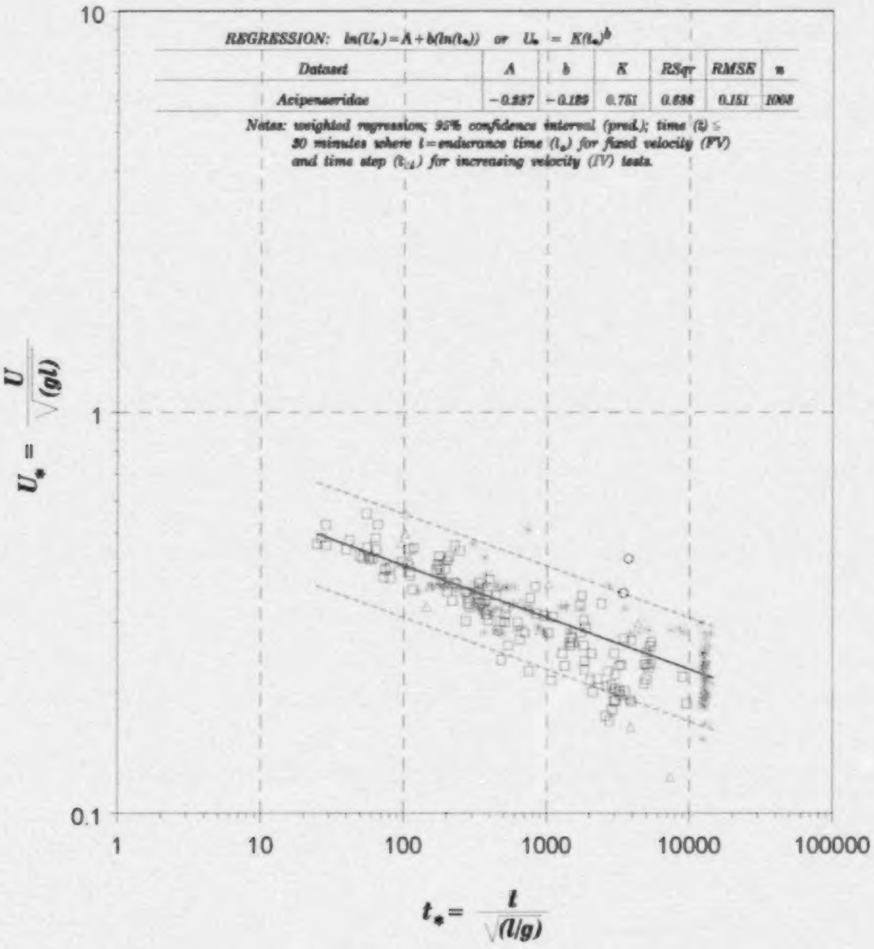


Figure D-2a. Processed data for Acipenseridae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Lake Sturgeon; red triangles are Pallid Sturgeon; green stars are Shortnose Sturgeon; black circles are Shovelnose Sturgeon; turquoise diamonds are White Sturgeon.

Table D-2a. Data summary. Fish count 1008, record count 278.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.225	0.16	0.066	1.32	1.254	109
T (C)	14.7	5.8	5	25	20	11
U (m/s)	0.435	0.196	0.15	1.8	1.65	97
t_e (s)	186	323	4	1797	1793	147
$t_{\Delta t}$ (s)	1459	544	120	1800	1680	5

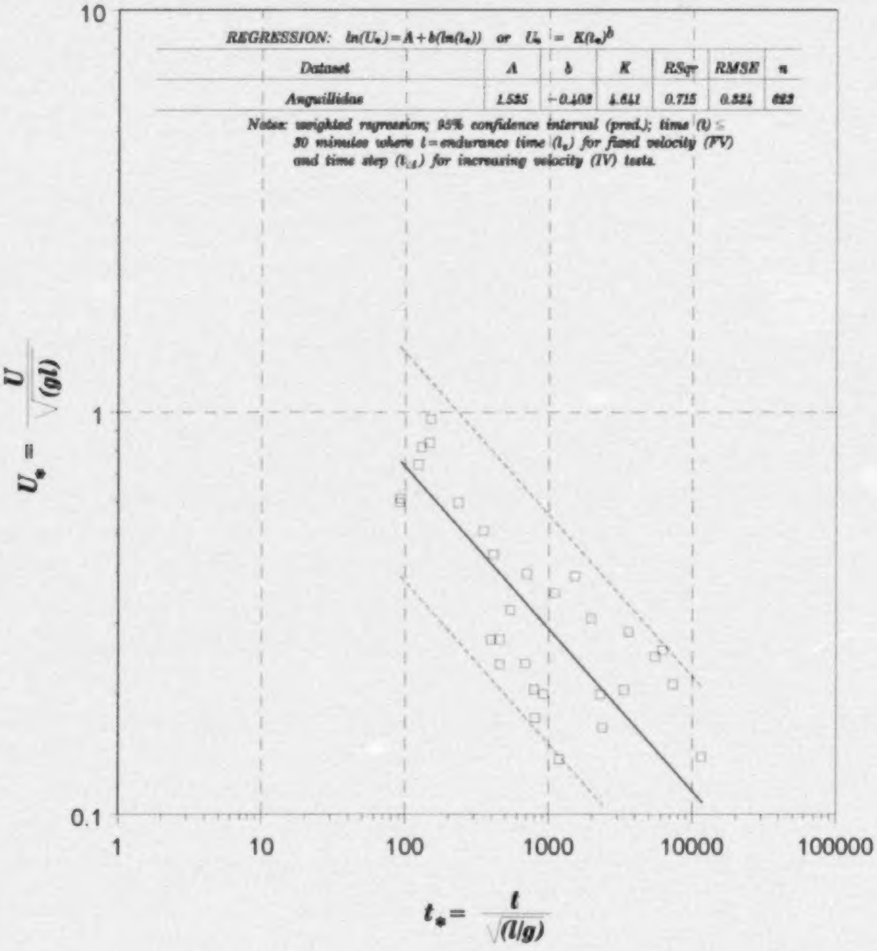


Figure D-2b. Processed data for Anguillidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are European Eel.

Table D-2b. Data summary. Fish count 623, record count 30.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.26	0.143	0.072	0.57	0.498	24
T (C)	15.3	3.6	10.2	23.5	13.3	17
U (m/s)	0.759	0.442	0.205	1.284	1.079	22
t_e (s)	302	437	20	1740	1720	16
$t_{\Delta t}$ (s)	20	0	20	20	0	1

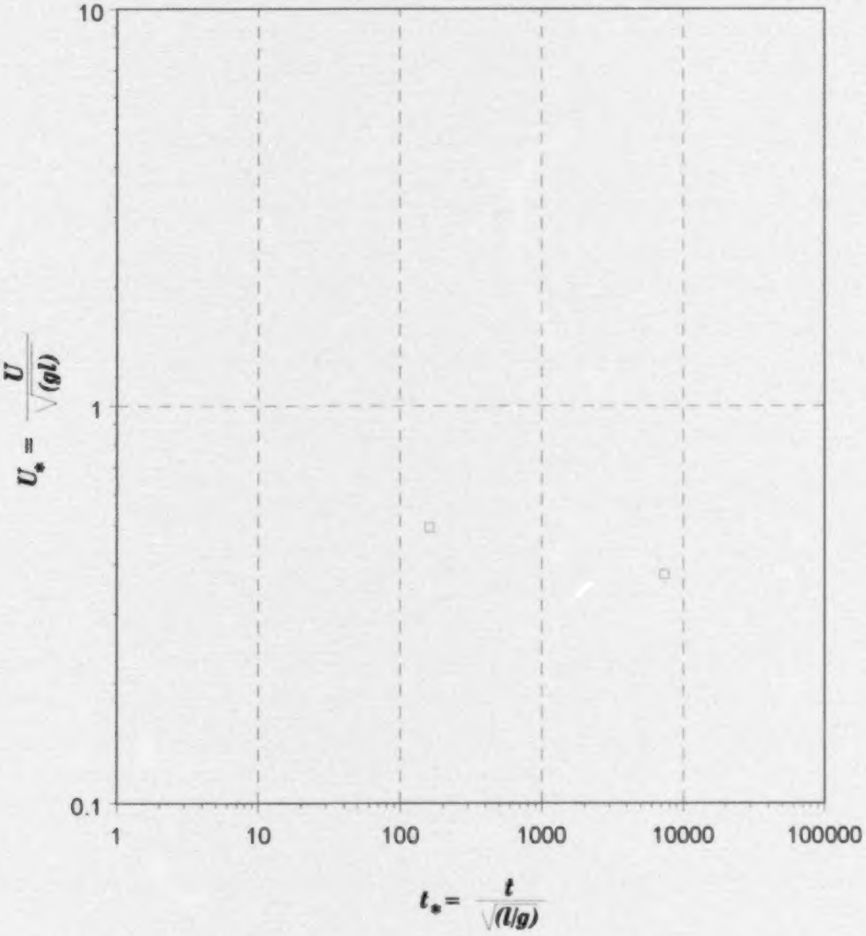


Figure D-2c. Processed data for Atherinidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Inland Silverside.

Table D-2c. Data summary. Fish count 26, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.056	0.013	0.038	0.065	0.027	2
T (C)	22.1	7.1	17	31.7	14.7	2
U (m/s)	0.301	0.001	0.3	0.302	0.002	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	396	286	10	600	590	2

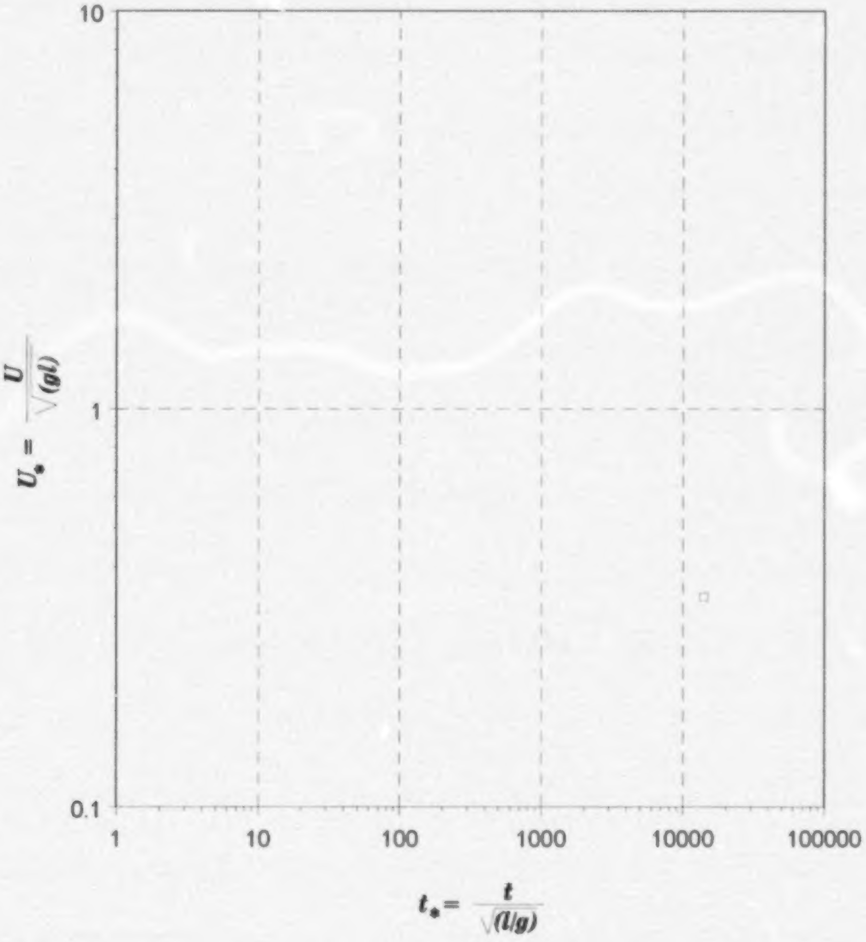


Figure D-2d. Processed data for Balitoridae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Stone Loach.

Table D-2d. Data summary. Fish count 8, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.072	0	0.072	0.072	0	1
T (C)	15	0	15	15	0	1
U (m/s)	0.283	0	0.283	0.283	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	1200	0	1200	1200	0	1

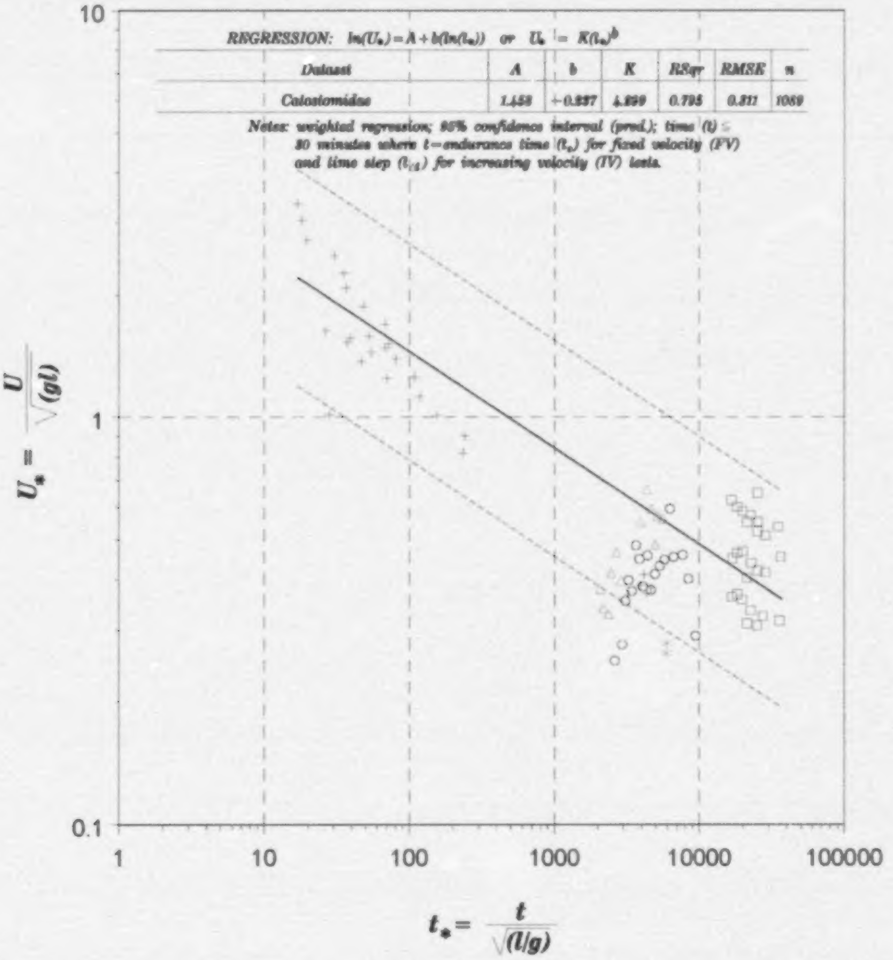


Figure D-2e. Processed data for Catostomidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Flannelmouth Sucker; red triangles are June Sucker; green stars are Largescale Sucker; black circles are Longnose Sucker; turquoise diamonds are Mountain Sucker; blue crosses are White Sucker.

Table D-2e. Data summary. Fish count 1008, record count 278.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.177	0.151	0.023	0.52	0.497	69
T (C)	14.4	3.2	10	20	10	8
U (m/s)	1.25	1.574	0.157	6.587	6.43	87
t_e (s)	1241	830	3	1800	1797	22
$t_{\Delta t}$ (s)	610	229	300	1200	900	3

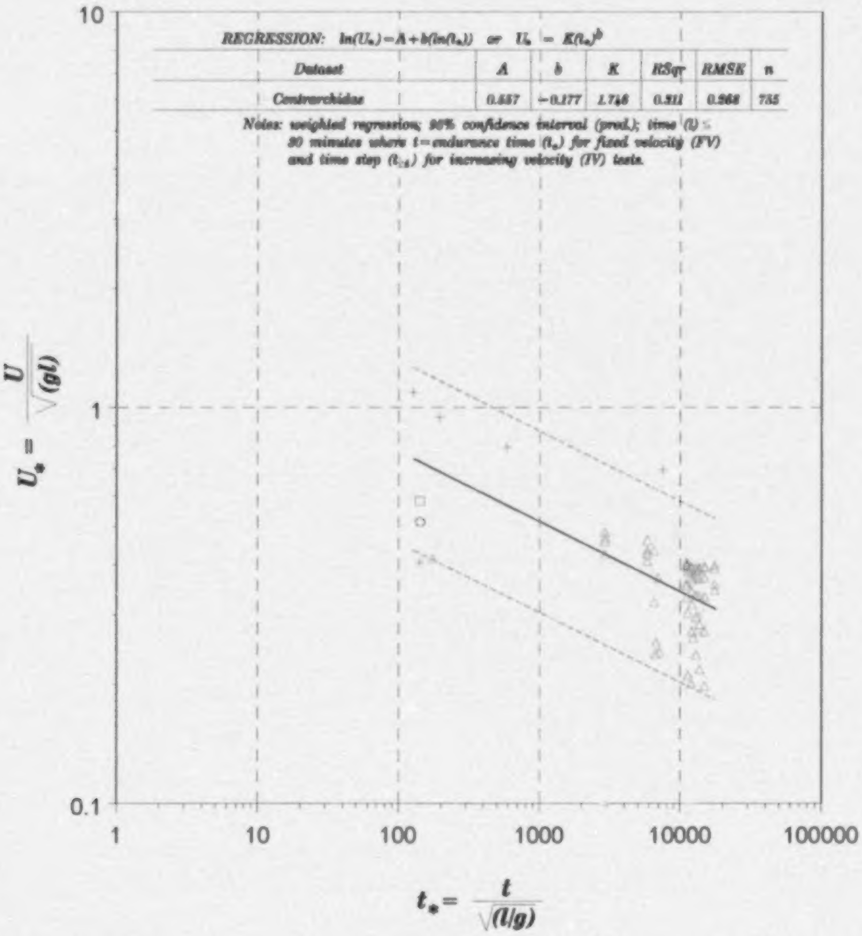


Figure D-2f. Processed data for Centrarchidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Bluegill; red triangles are Largemouth Bass; green stars are Longear Sunfish; black circles are Redbreast Sunfish; turquoise diamonds are Smallmouth Bass; blue crosses are Sunfish; red x's are White Crappie.

Table D-2f. Data summary. Fish count 755, record count 81.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.154	0.081	0.032	0.424	0.392	35
T (C)	18.6	7.1	5	34	29	25
U (m/s)	0.466	0.225	0.2	1.1	0.9	77
t_e (s)	216	329	13	770	757	4
$t_{\Delta t}$ (s)	1097	544	10	1800	1790	6

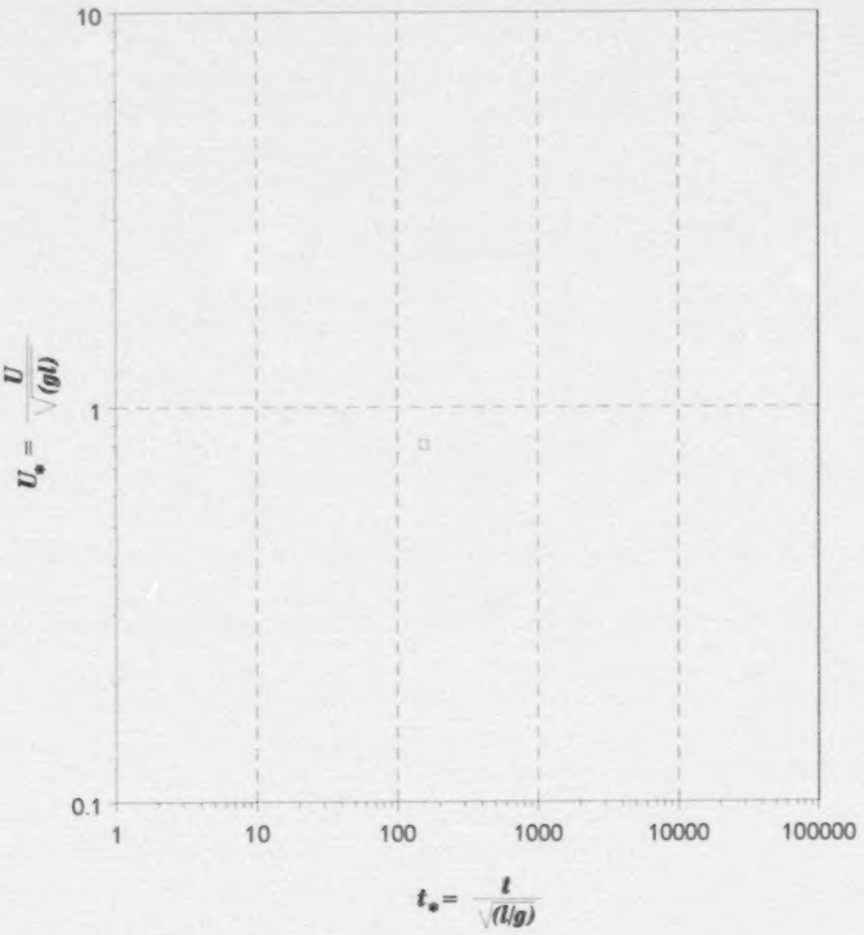


Figure D-2g. Processed data for Characidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue square is Mexican tetra.

Table D-2g. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.041	0	0.041	0.041	0	1
T (C)	24.9	0	24.9	24.9	0	1
U (m/s)	0.509	0	0.509	0.509	0	1
t_e (s)	.	.		.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

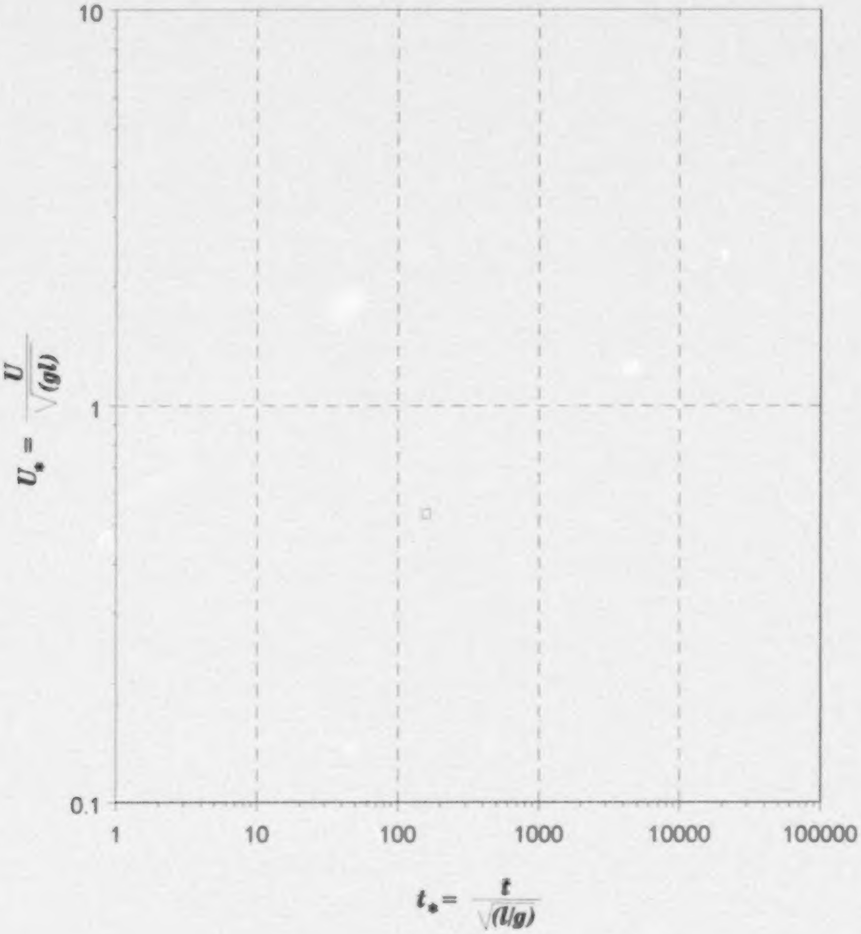


Figure D-2h. Processed data for Cichlidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Rio Grande Cichlid.

Table D-2h. Data summary. Fish count 8, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.039	0	0.039	0.039	0	1
T (C)	25.6	0	25.6	25.6	0	1
U (m/s)	0.33	0	0.33	0.33	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

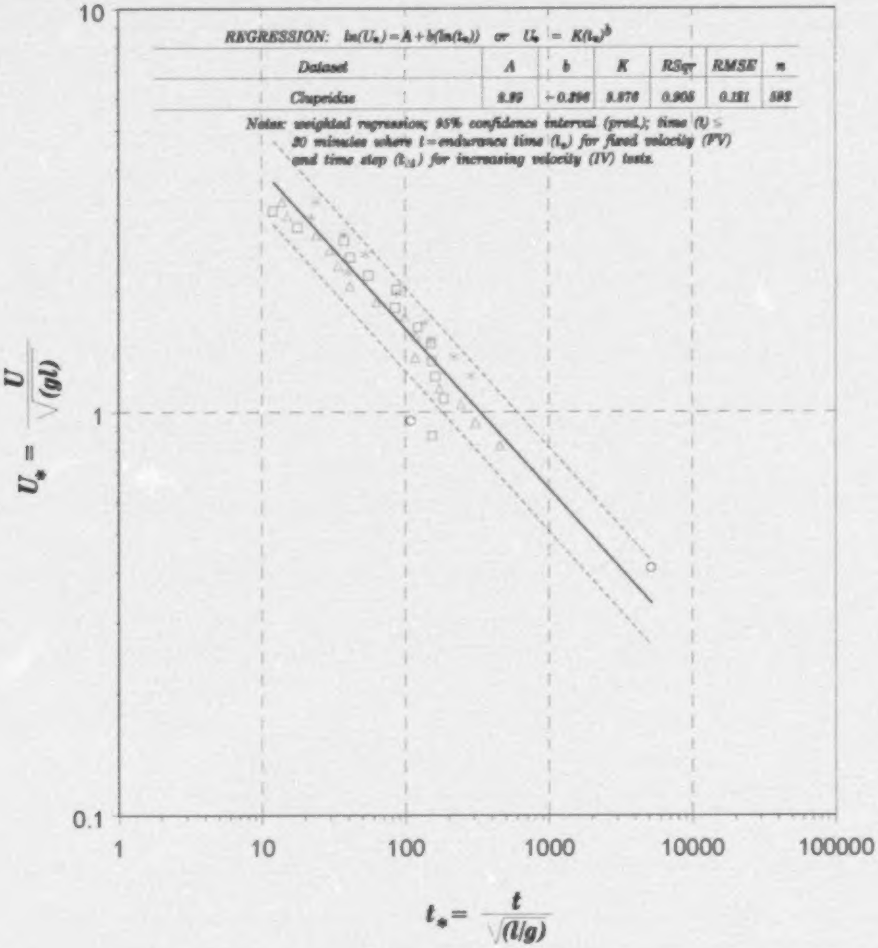


Figure D-2i. Processed data for Clupeidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Alewife; red triangles are American Shad; green stars are Blueback Herring; black circles are Twaite Shad.

Table D-2i. Data summary. Fish count 592, record count 39.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.328	0.092	0.209	0.418	0.199	9
T (C)	15.4	3.7	10.4	20.4	10	5
U (m/s)	3.452	1.279	0.75	6.71	5.96	39
t_e (s)	26	89	2	960	958	38
$t_{\Delta t}$ (s)	20	0	20	20	0	1

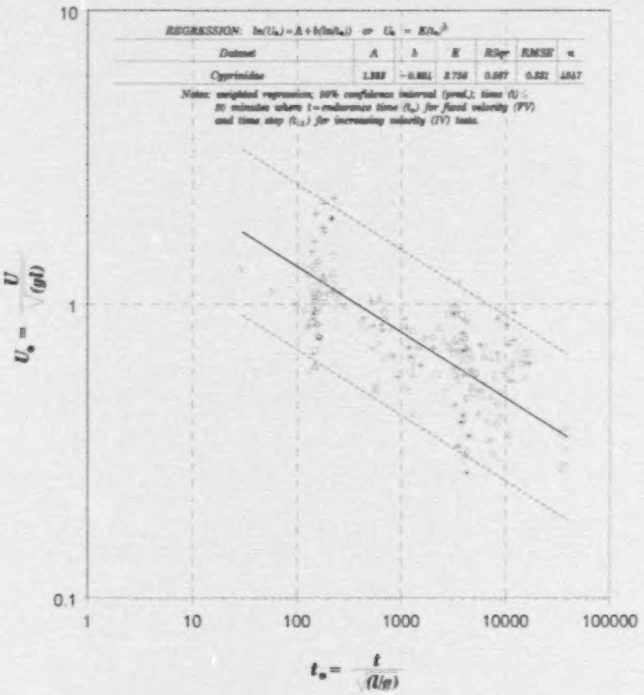


Figure D-2j. Processed data for Cyprinidae: dimensionless time-to-fatigue versus dimensionless swim speed. Black crosses are Barbel; green crosses are Blackspot Shiner; turquoise crosses are Bonytail Chub; yellow crosses are Bullhead Minnow; black x's are Central Stoneroller; green x's are Creek Chub; turquoise x's are Dace; yellow x's are European Chub; black stars are Flathead Chub; green stars are Gudgeon; turquoise stars are Least Chub; yellow stars are Mimic Shiner; black squares are Plains Minnow; green squares are Red River Shiner; turquoise squares are Redfin Shiner; yellow squares are Ribbon Shiner; black diamonds are Sabine Shiner; green diamonds are Sand Shiner; turquoise diamonds are Silverband Shiner; yellow diamonds are Smalleye Shiner; black triangles are Speckled Chub; green triangles are Spottail Shiner; turquoise triangles are Texas Shiner; yellow triangles are Weed Shiner; red crosses are Blacknose Dace; blue crosses are Blacktail Shiner; fuschia crosses are Bream; grey crosses are Carp; red x's are Colorado Squawfish; blue x's are Crucian Carp; fuschia x's are Emerald Shiner; grey x's are Fathead Minnow; red stars are Ghost Shiner; blue stars are Humpback Chub; fuschia stars are Longnose Dace; grey stars are Northern Squawfish; red squares are Proserpine Shiner; blue squares are Red Shiner; fuschia squares are Redside Shiner; grey squares are Roach; red diamonds are Sacramento Splittail; blue diamonds are Sharpnose Shiner; fuschia diamonds are Silvery Minnow; grey diamonds are Southern Leatherside Chub; red triangles are Speckled Dace; blue triangles are Striped Shiner; fuschia triangles are Topeka Shiner.

Table D-2j. Data summary. Fish count 4947 record count 243.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.109	0.069	0.021	0.451	0.43	146
T (C)	15.4	5.9	4.1	32.9	28.8	97
U (m/s)	0.865	0.544	0.13	2.635	2.505	185
t_e (s)	523	527	3	1800	1797	76
$t_{\Delta t}$ (s)	199	383	10	1800	1790	7

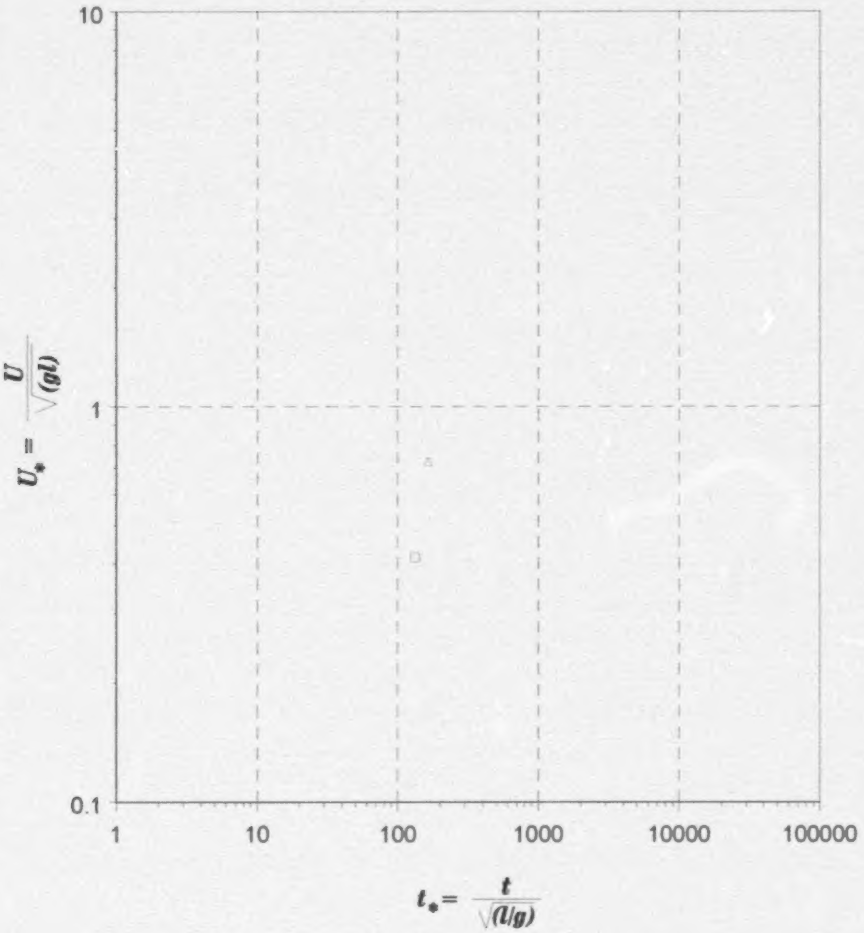


Figure D-2k. Processed data for Cyprinodontidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Blackstripe Topminnow; red traingles are Plains Killifish.

Table D-2k. Data summary. Fish count 20, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.046	0.01	0.036	0.056	0.019	2
T (C)	26	2.4	23.6	28.3	4.7	2
U (m/s)	0.371	0.065	0.307	0.434	0.127	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

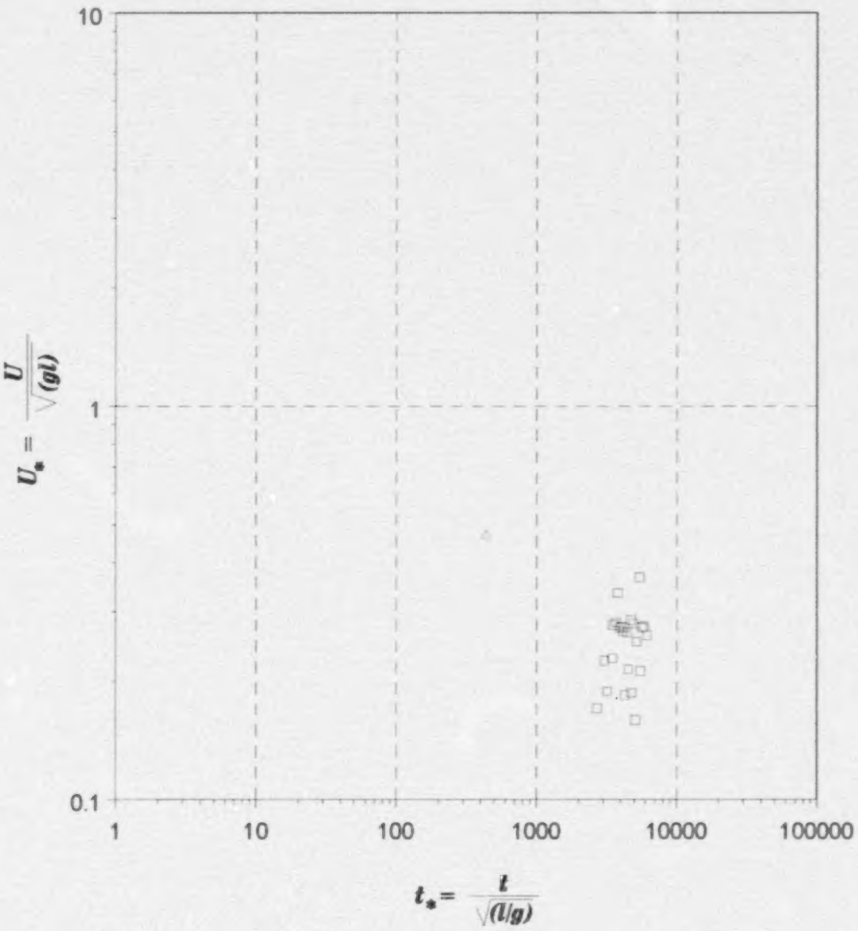


Figure D-2l. Processed data for Esocidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Northern Pike; red triangles are Tiger Muskellunge.

Table D-2l. Data summary. Fish count 138, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.114	0.094	0.024	0.48	0.456	26
T (C)	17.2	3.9	12	25	13	3
U (m/s)	0.252	0.125	0.126	0.642	0.516	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	380	165	60	600	540	3

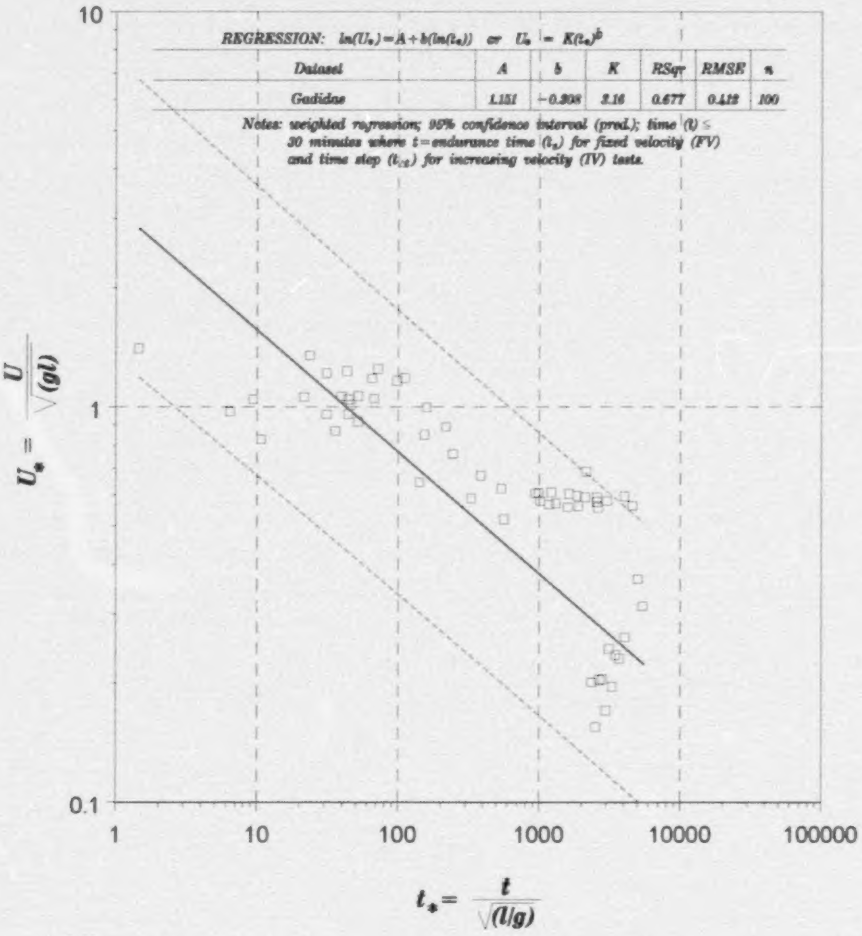
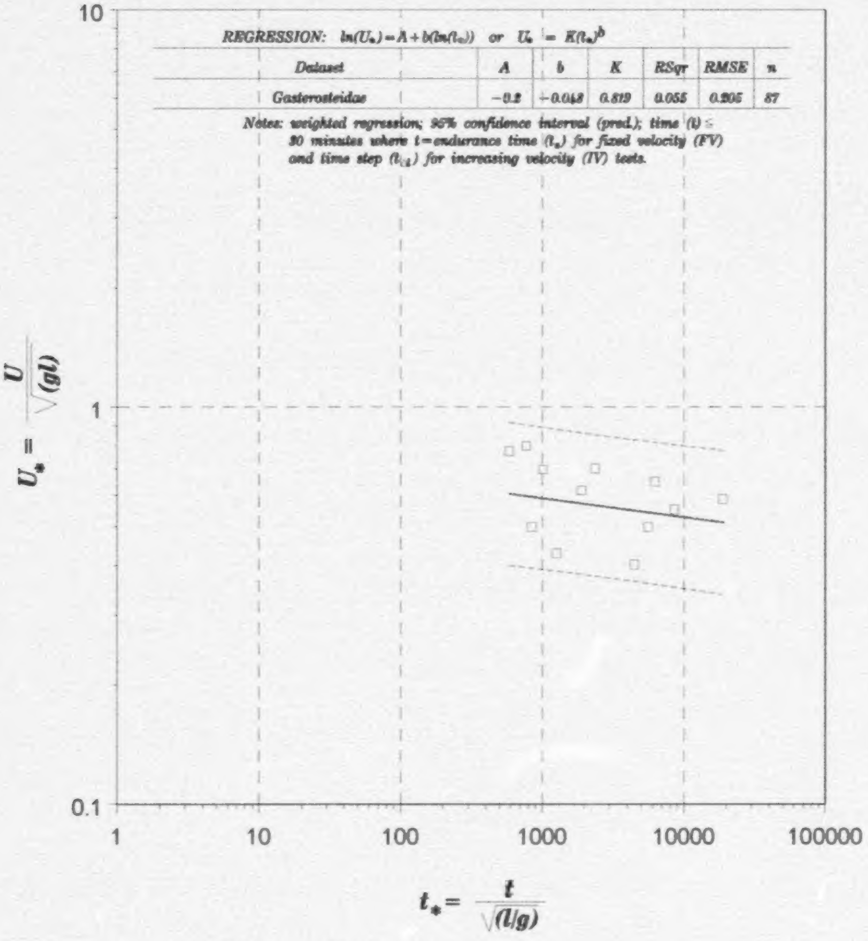


Figure D-2m. Processed data for Gadidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Burbot.

Table D-2m. Data summary. Fish count 100, record count 60.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.296	0.135	0.12	0.63	0.51	34
T (C)	13.8	4	10	18	8	2
U (m/s)	0.753	0.45	0.339	1.91	1.571	56
t_e (s)	117	156	0	635	635	47
$t_{\Delta t}$ (s)	600	0	600	600	0	1



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Gasterosteidae	−0.2	−0.048	0.819	0.055	0.205	87

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure D-2n. Processed data for Gasterosteidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Threespine stickleback.

Table D-2n. Data summary. Fish count 87, record count 12.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.05	0.005	0.044	0.055	0.011	3
T (C)	16.6	2.3	15	20	5	2
U (m/s)	0.403	0.086	0.264	0.571	0.307	12
t_e (s)	309	324	44	1261	1217	12
$t_{\Delta t}$ (s)	.	.	.	.	.	0

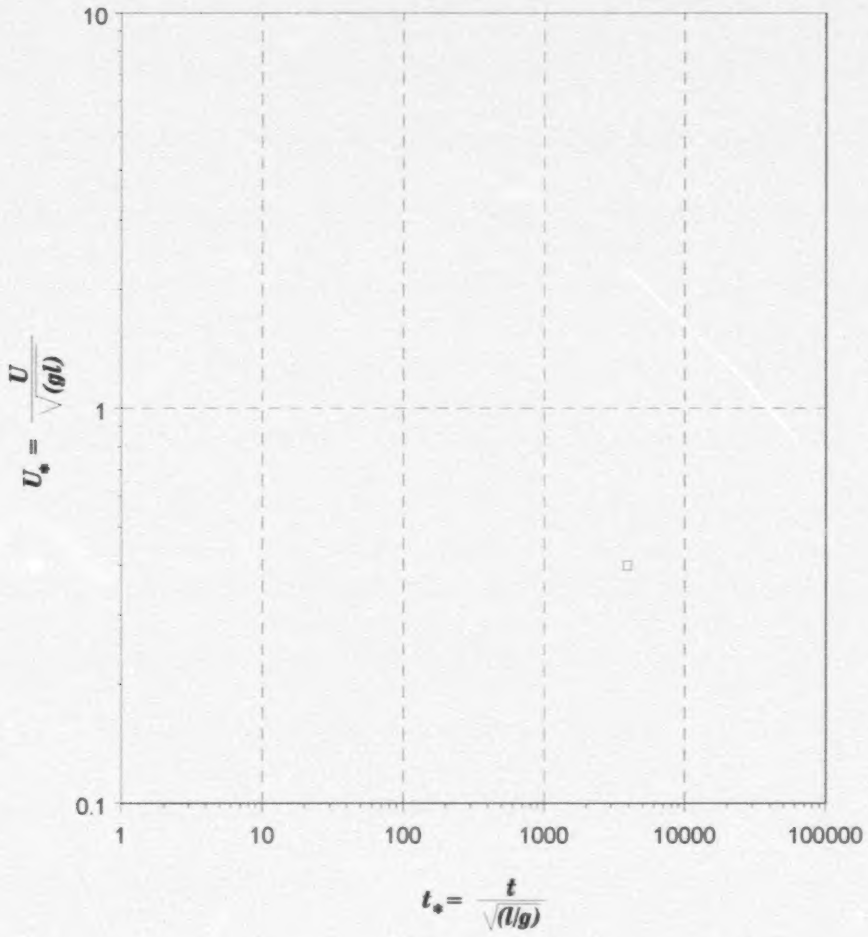


Figure D-2o. Processed data for Hiodontidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Goldeye.

Table D-2o. Data summary. Fish count 2, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.23	0	0.23	0.23	0	1
T (C)	16	0	16	16	0	1
U (m/s)	0.6	0	0.6	0.6	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	600	0	600	600	0	1

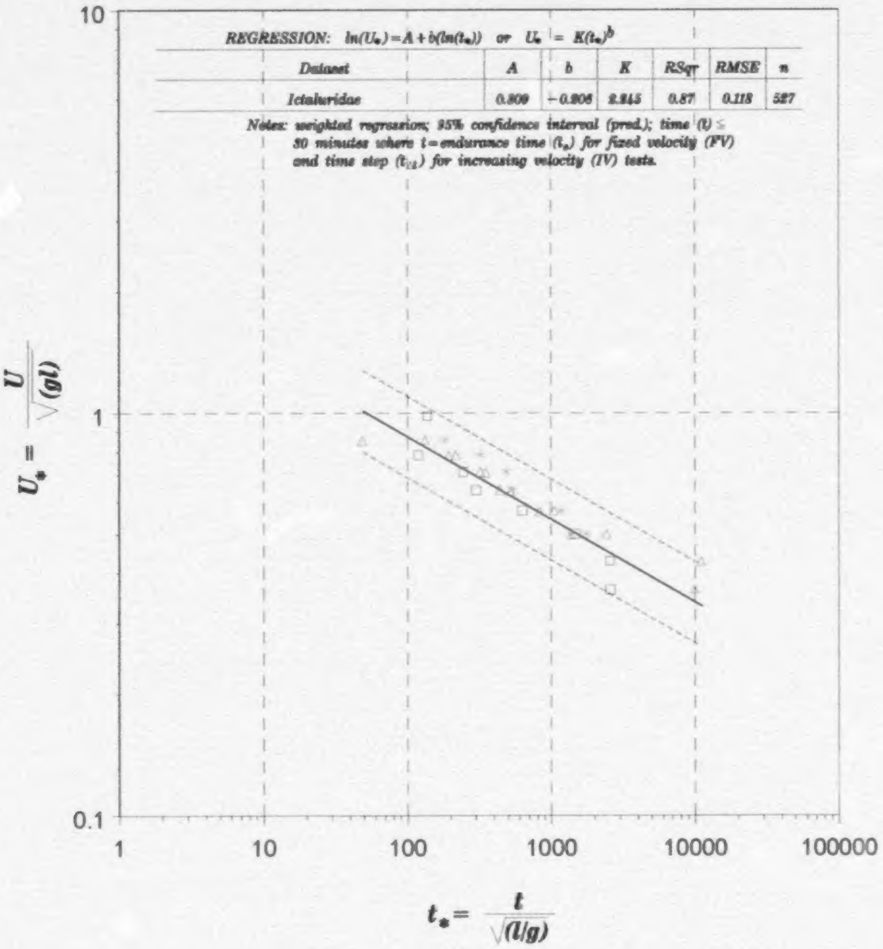


Figure D-2p. Processed data for Ictaluridae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Blue Catfish; red triangles are Channel Catfish; green stars are channel x blue hybrid catfish.

Table D-2p. Data summary. Fish count 527, record count 34.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.226	0.044	0.052	0.277	0.225	5
T (C)	20.6	1.3	20	29.6	9.6	3
U (m/s)	0.791	0.208	0.6	1.2	0.6	7
t_e (s)	498	617	7	1656	1649	26
$t_{\Delta t}$ (s)	10	0	10	10	0	1

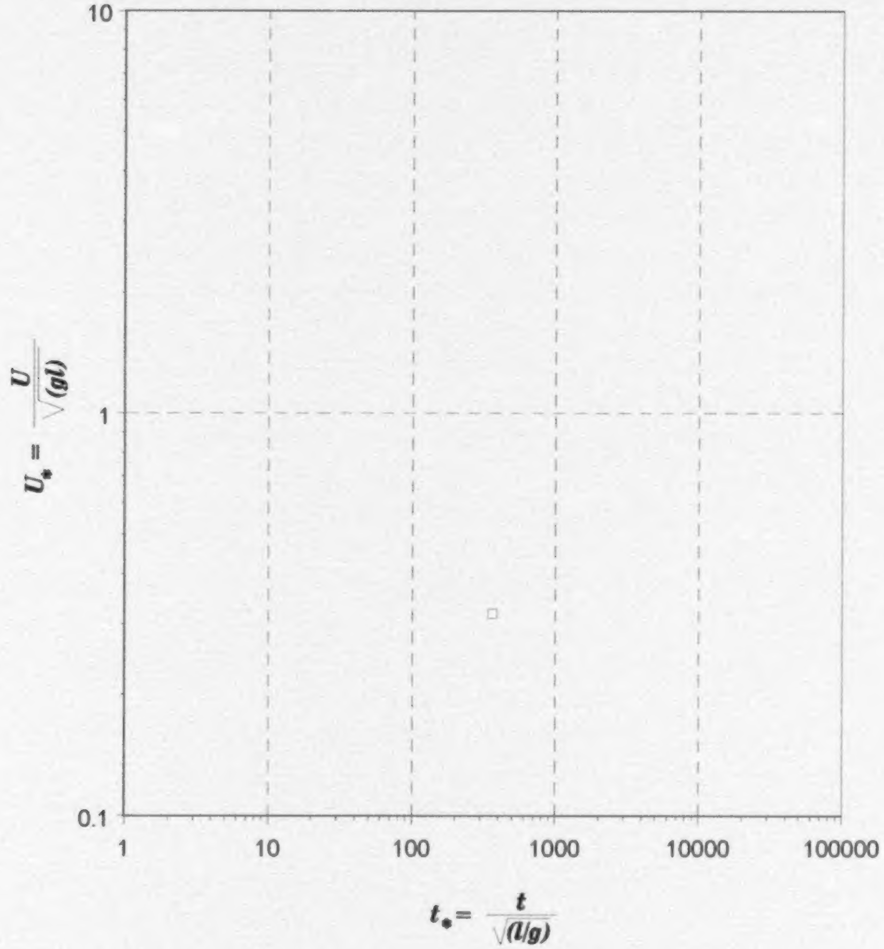


Figure D-2q. Processed data for Lepisosteidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Longnose Gar.

Table D-2q. Data summary. Fish count 10, record count 1.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.266	0	0.266	0.266	0	1
T (C)	25	0	25	25	0	1
U (m/s)	0.514	0	0.514	0.514	0	1
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	60	0	60	60	0	1

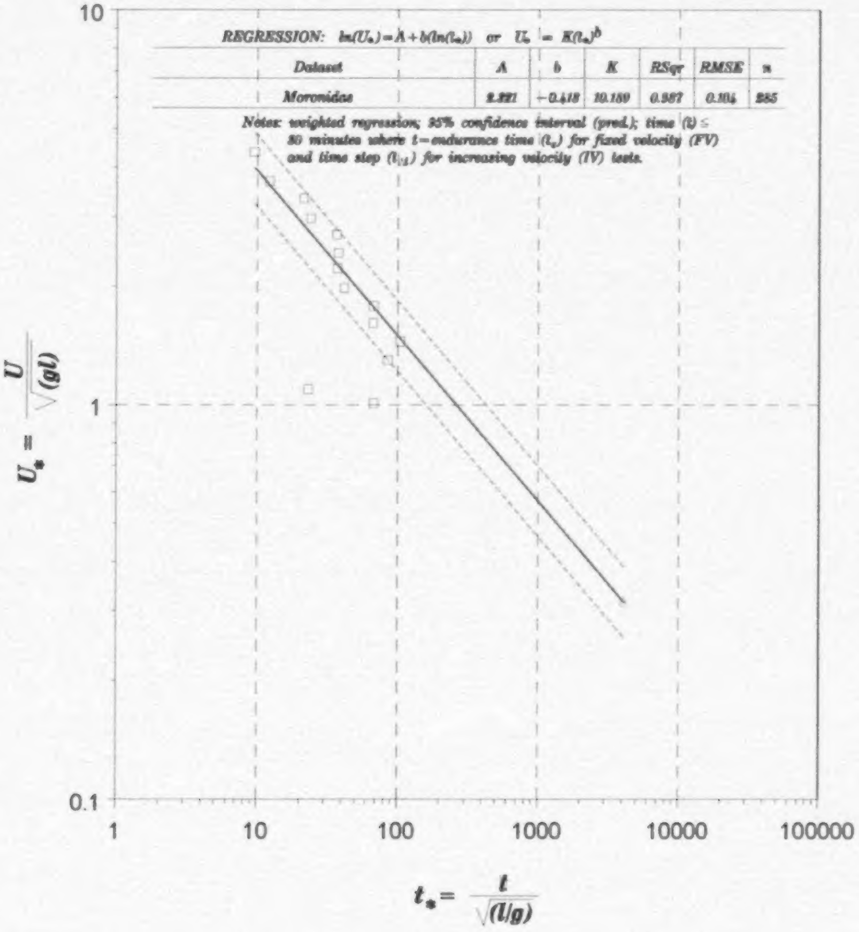


Figure D-2r. Processed data for Moronidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Striped Bass; red triangles are White Perch.

Table D-2r. Data summary. Fish count 285, record count 15.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.403	0.102	0.264	0.478	0.214	6
T (C)	19.8	1.2	18.9	21.5	2.6	2
U (m/s)	3.204	2.21	0.51	9.45	8.94	15
t_e (s)	242	315	2	670	668	15
$t_{\Delta t}$ (s)	.	.	.	.	.	0

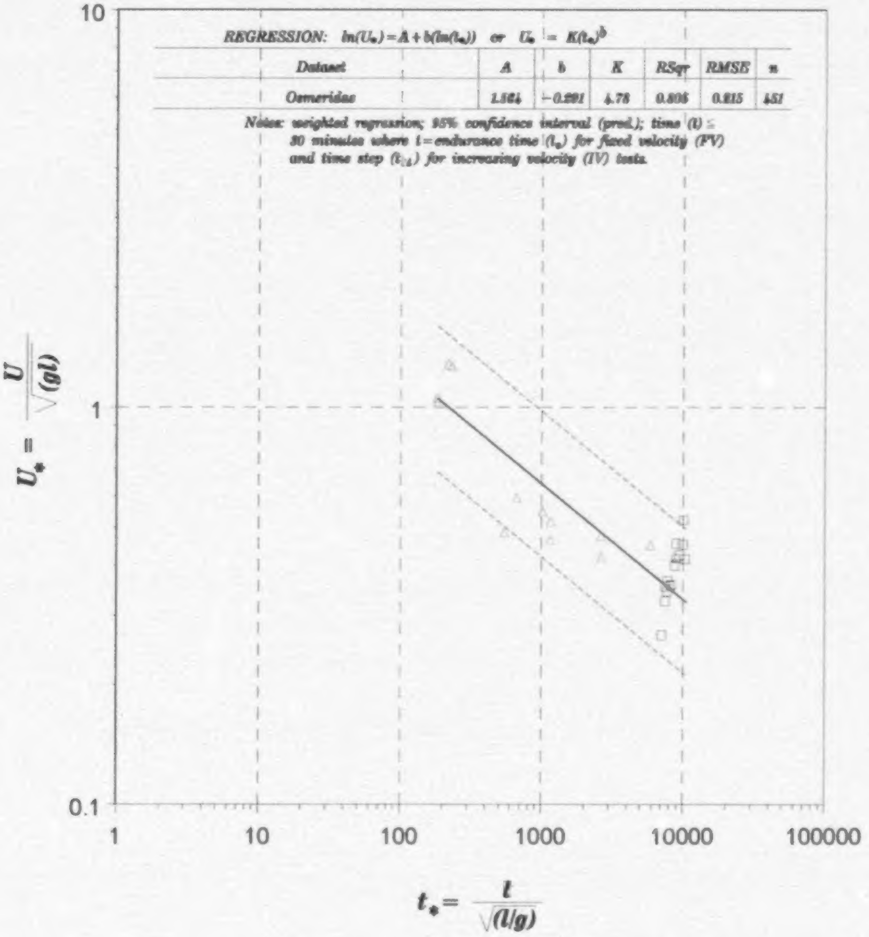


Figure D-2s. Processed data for Osmeridae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Delta Smelt; red triangles are European Smelt.

Table D-2s. Data summary. Fish count 451, record count 27.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.092	0.023	0.033	0.033	0.087	25
T (C)	12.6	3.7	6	21	15	13
U (m/s)	0.705	0.353	0.223	1.154	0.931	21
t_e (s)	268	293	60	930	870	6
$t_{\Delta t}$ (s)	182	261	20	600	580	2

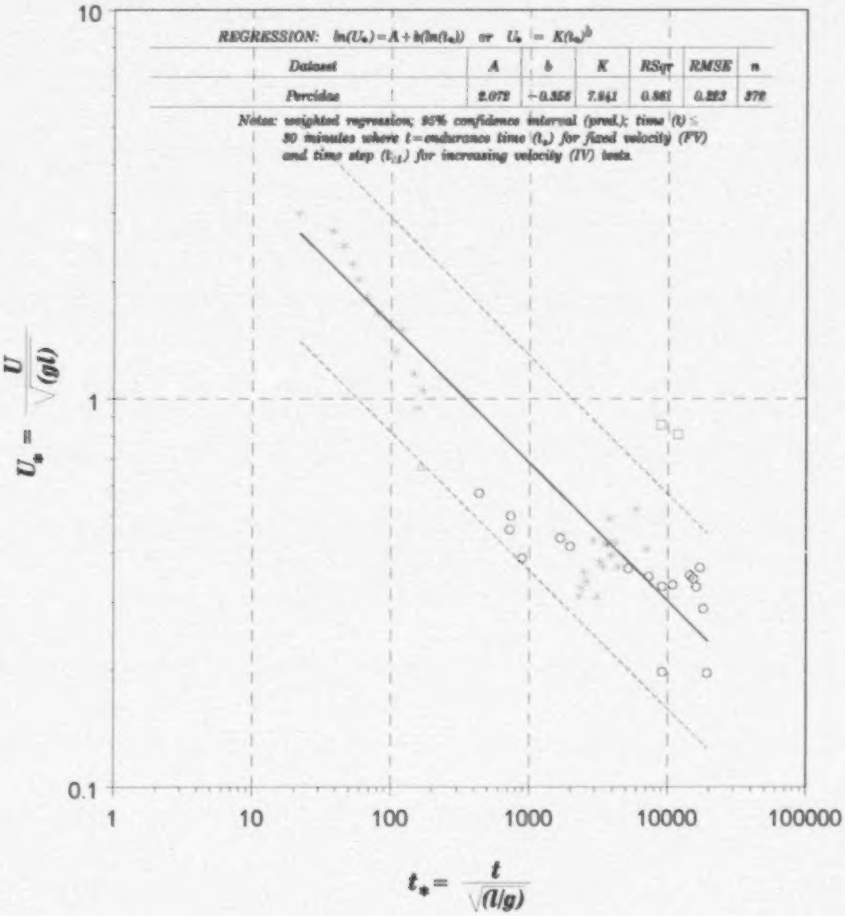


Figure D-2t. Processed data for Percidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are European Perch; red triangles are Rio Grande Darter; green stars are Walleye; black circles are Yellow Perch.

Table D-2t. Data summary. Fish count 372, record count 48.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.244	0.139	0.036	0.665	0.629	36
T (C)	15.8	3.7	10	24.1	14.1	8
U (m/s)	1.711	1.618	0.18	5.292	5.112	39
t_e (s)	89	183	4	854	850	20
$t_{\Delta t}$ (s)	954	466	10	1800	1790	5

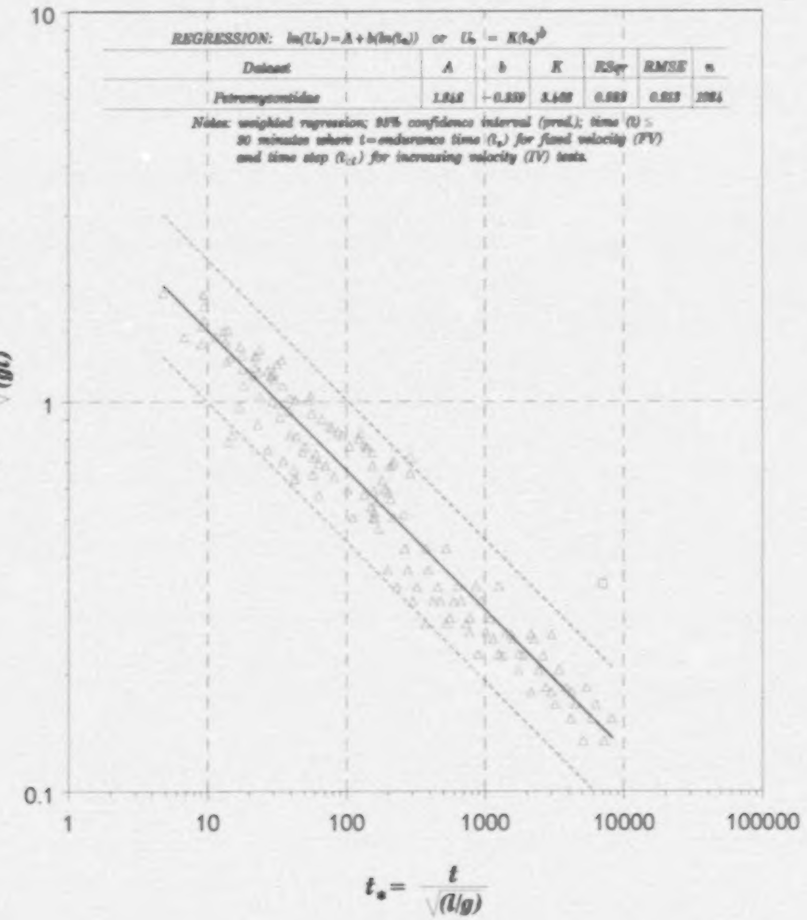


Figure D-2u. Processed data for Petromyzontidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue square is Pacific Lamprey; red triangles are Sea Lamprey.

Table D-2u. Data summary. Fish count 1024, record count 152.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.398	0.128	0.145	0.641	0.496	66
T (C)	12.4	5.1	5	23	18	55
U (m/s)	1.256	1.098	0.3	3.961	3.661	90
t_e (s)	216	343	1	1635	1634	99
$t_{\Delta t}$ (s)	1800	0	1800	1800	0	1

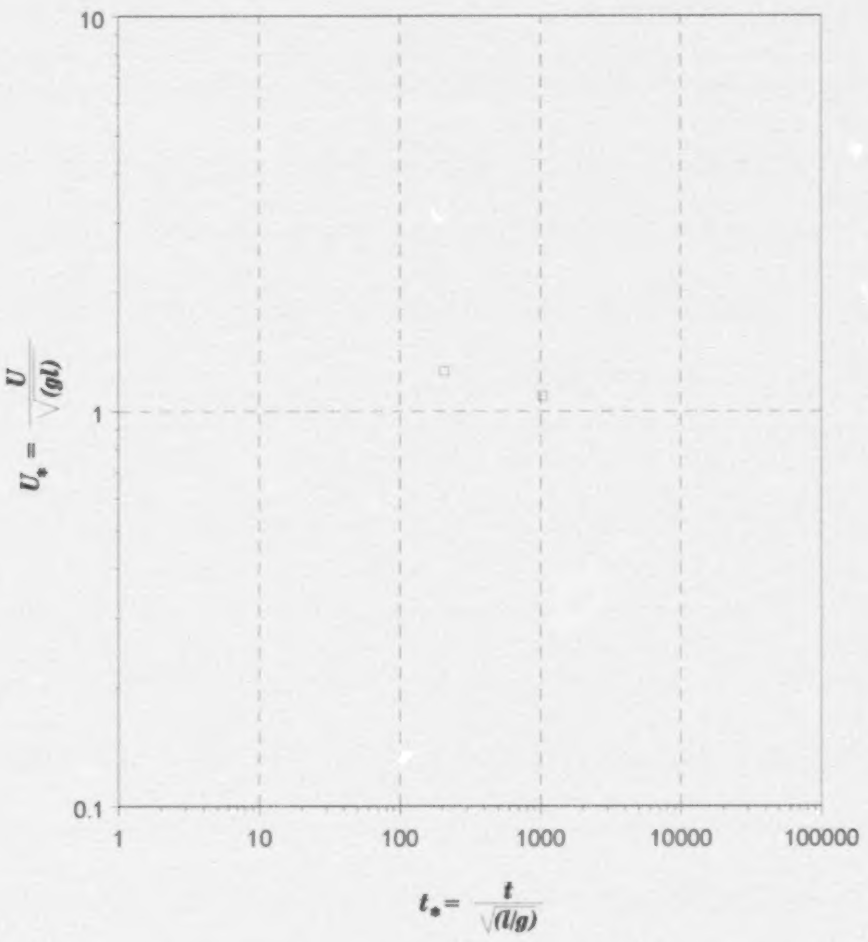


Figure D-2v. Processed data for Plecoglossidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Ayu.

Table D-2v. Data summary. Fish count 20, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.144	0	0.144	0.144	0	1
T (C)	18	0	18	18	0	1
U (m/s)	1.4	0.103	1.3	1.5	0.2	2
t_e (s)	76	52	25	126	101	2
$t_{\Delta t}$ (s)	.	.	.	.	.	0

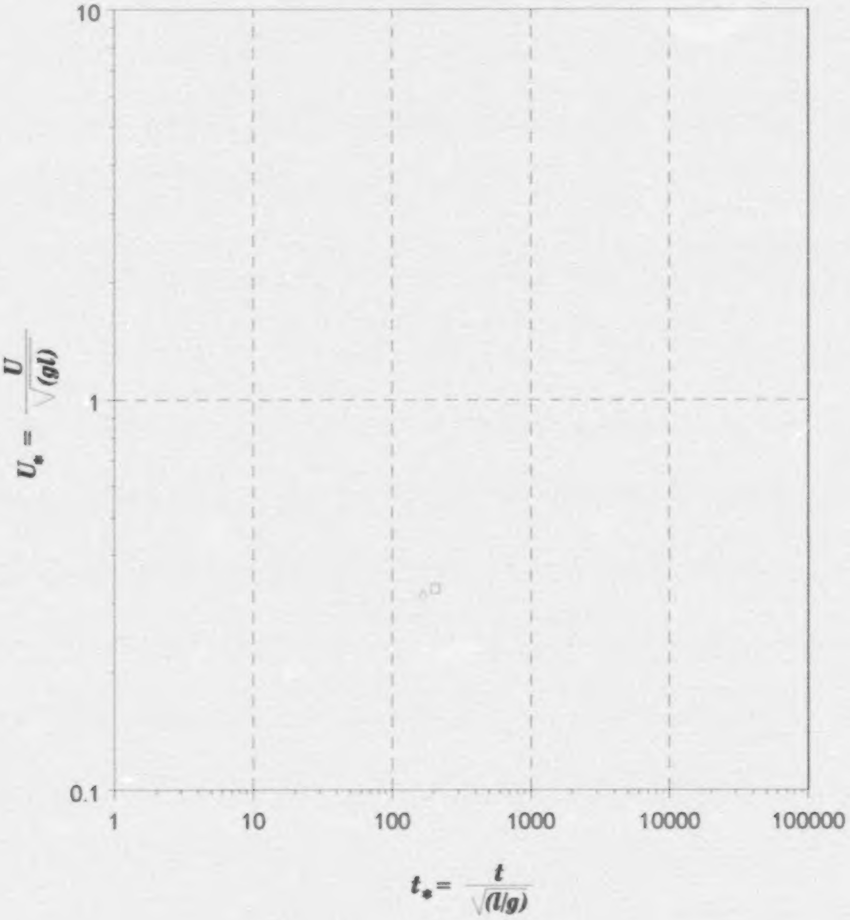


Figure D-2w. Processed data for Poeciliidae: dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Largespring Gambusia; red triangles are Sailfin Molly.

Table D-2w. Data summary. Fish count 12, record count 2.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.028	0.006	0.023	0.035	0.012	2
T (C)	22.7	0	22.7	22.7	0	1
U (m/s)	0.169	0.015	0.157	0.186	0.029	2
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	10	0	10	10	0	1

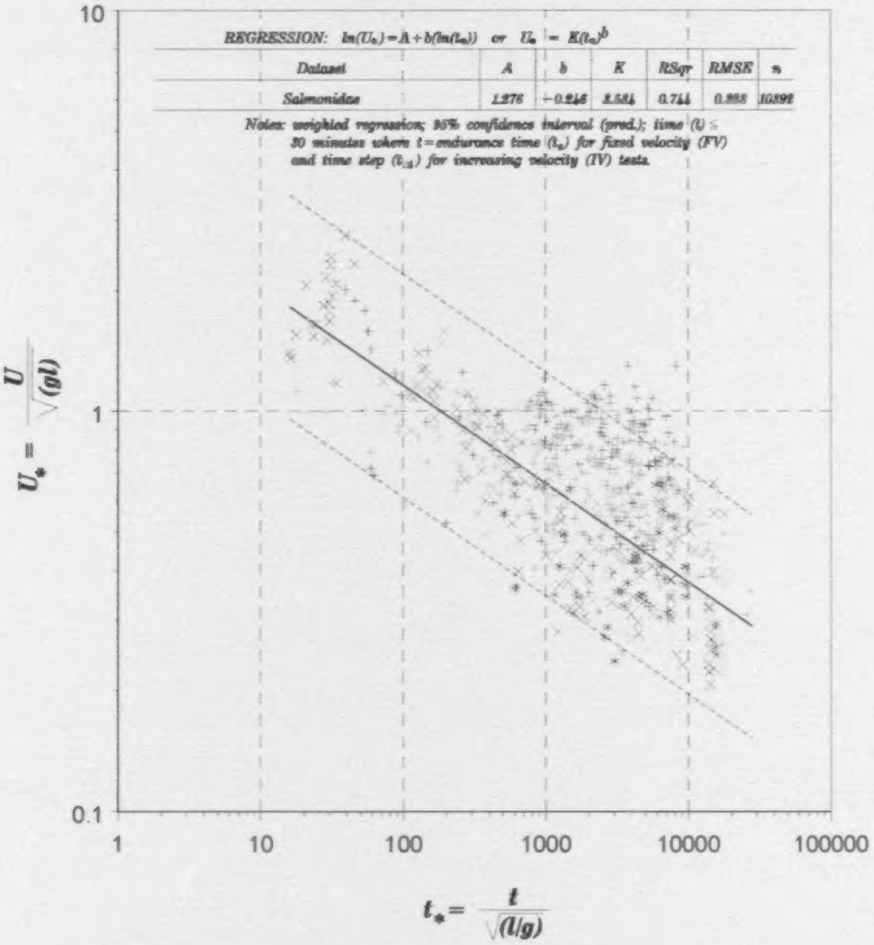


Figure D-2x. Processed data for Salmonidae: dimensionless time-to-fatigue versus dimensionless swim speed. Black crosses are Arctic Char; green crosses are Arctic Grayling; turquoise crosses are Broad Whitefish, yellow crosses are Brown Trout; black x's are Chinook Salmon; green x's are Cisco; turquoise x's are Cutthroat Trout; yellow x's are Inconnu; black stars are Lake Whitefish; green stars are Mountain Whitefish; turquoise stars are Rainbow Trout; yellow stars are Steelhead Trout; red crosses are Arctic Cisco; blue crosses are Atlantic Salmon; fuschia crosses are Brook Trout; grey crosses are BullTrout; red x's are Chum Salmon; blue x's are Coho Salmon; fuschia x's are European Grayling; grey x's are Lake Trout; red stars are Least Cisco; blue stars are Pink Salmon; fuschia stars are Sockeye Salmon.

Table D-2x. Data summary. Fish count 10392, record count 897.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.234	0.226	0.024	0.927	0.903	458
T (C)	12.9	4.7	3.1	21.2	18.1	127
U (m/s)	1.29	1.397	0.11	6.406	6.296	494
t_e (s)	281	370	2	1800	1798	285
$t_{\Delta t}$ (s)	680	505	10	1800	1790	10

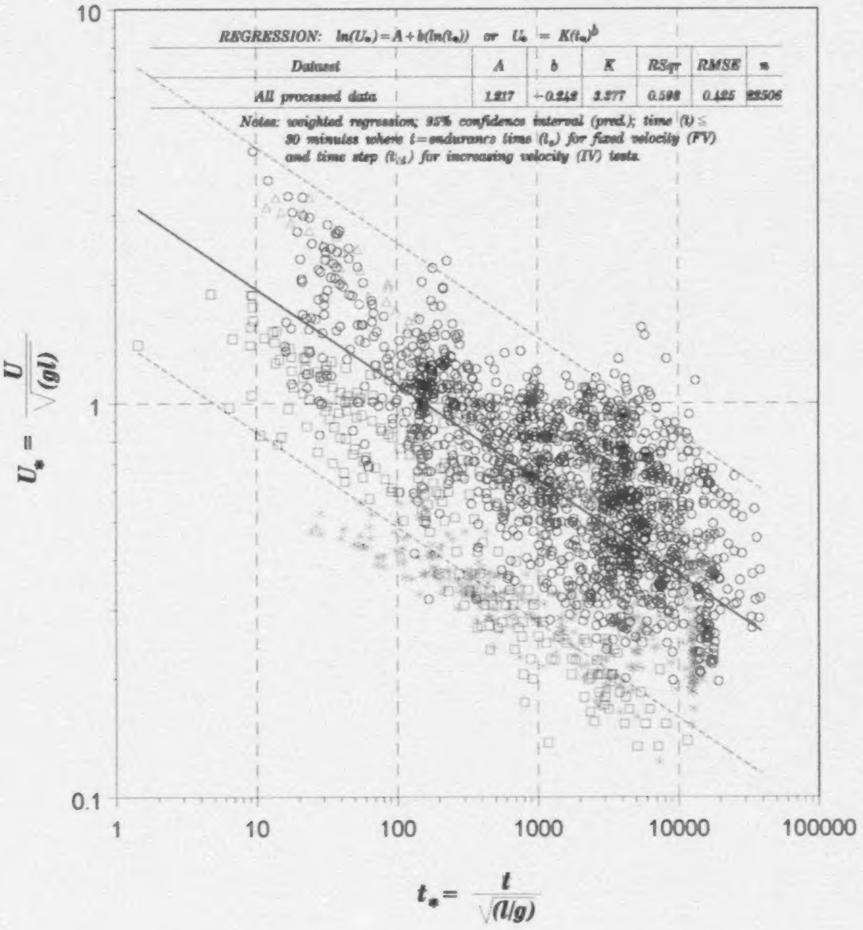
APPENDIX 1–SERIES E

Processed Endurance Data

Dimensionless Swim Speed (U_*) vs Dimensionless Time-to-Fatigue (t_*)

Plotted by Swim Mode (5 graphs)

- Details on swim mode are described in the report text.
- Three main swimming modes (anguilliform, carangiform and subcarangiform) were plotted using all processed data. These were the most dominant swimming modes. The swim mode labeled “Other” was used for species that used a combination of modes or for species where the swimming mode was not defined.
- Plots show a separation of data based on swimming mode. This information was utilized in the creation of data groupings to reflect similarities in swimming performance.
- Many fish species use different swimming modes based on activity level requirements, and the classification used reflects the dominant swimming mode which, in some cases, may be open to interpretation.



REGRESSION: $\ln(U_*)=A+b(\ln(t_*))$ or $U_* = K(t_*)^b$

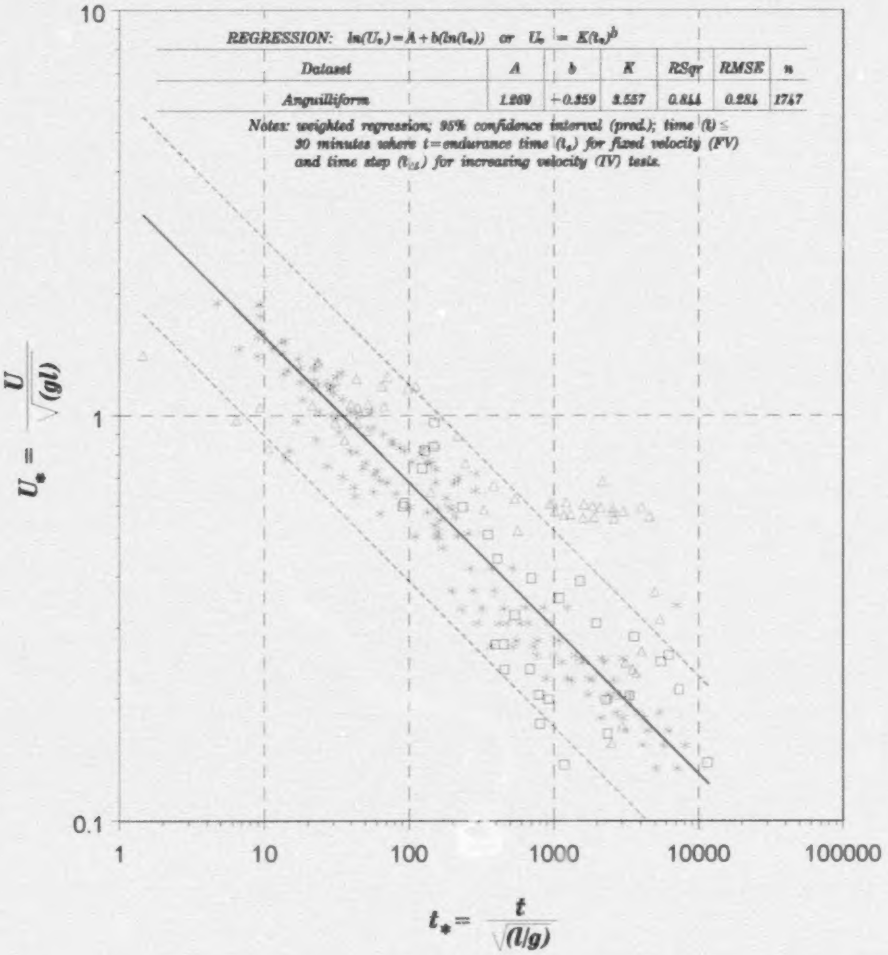
Dataset	A	b	K	RSqr	RMSE	n
All processed data	1.217	−0.248	3.377	0.598	0.425	22506

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t=endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure E-1. Processed endurance data: dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are Anguilliform; red triangles are Carangiform; black circles are Subcarangiform; green stars are "other" or unspecified swim modes.*

Table E-1. Data summary. Fish count 22506, record count 2045.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.209	0.187	0.021	1.32	1.299	724
T (C)	14.3	5.3	3.1	34	30.9	233
U (m/s)	1.161	1.26	0.11	9.45	9.34	997
t_e (s)	376	517	0	1800	1800	589
$t_{\Delta t}$ (s)	588	567	10	1800	1790	12



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Anguilliform	1.269	−0.359	3.557	0.844	0.284	1747

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure E-2a. Processed endurance data for Anguilliform swim mode: dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are Anguillidae; red triangles are Gadidae; green stars are Petromyzontidae.*

Table E-2a. Data summary. Fish count 1747, record count 242.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.343	0.149	0.072	0.641	0.569	116
T (C)	13.5	4.7	5	23.5	18.5	70
U (m/s)	1.05	0.921	0.205	3.961	3.756	160
t_e (s)	234	366	0	1740	1740	157
$t_{\Delta t}$ (s)	225	471	20	1800	1780	3

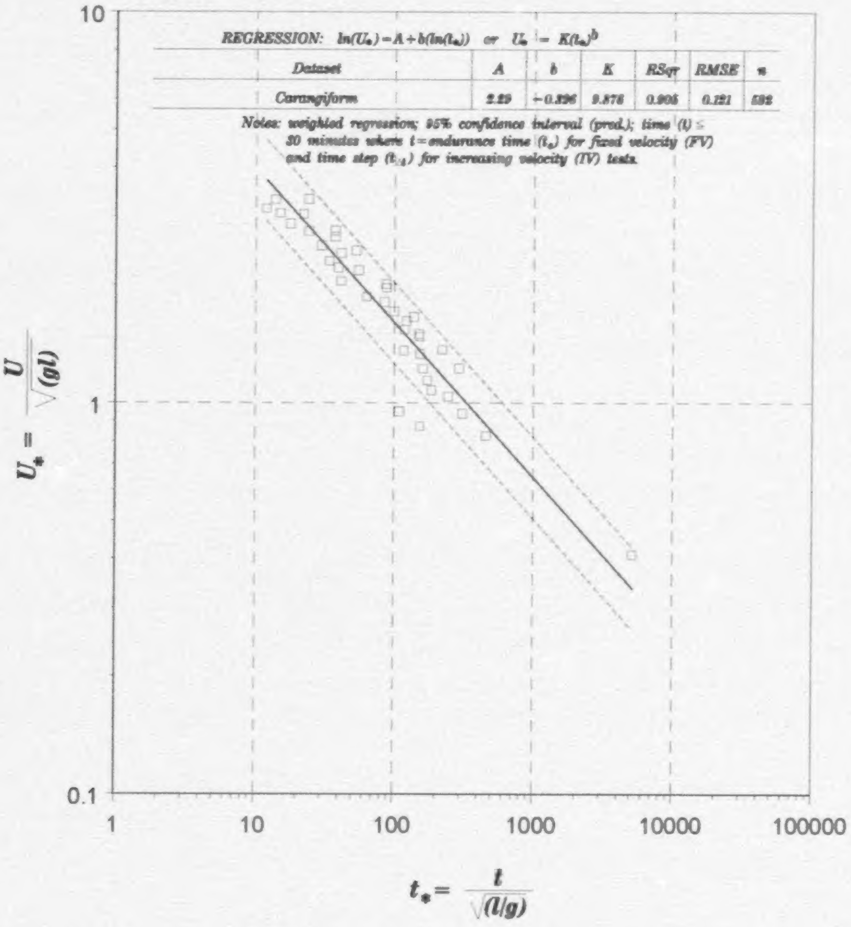


Figure E-2b. Processed endurance data for Carangiform swim mode: dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are Clupeidae.*

Table E-2b. Data summary. Fish count 592, record count 39.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.328	0.092	0.219	0.418	0.199	9
T (C)	15.4	3.7	10.4	20.4	10	5
U (m/s)	3.452	1.279	0.75	6.71	5.96	39
t_e (s)	26	89	2	960	958	38
$t_{\Delta t}$ (s)	20	0	20	20	0	1

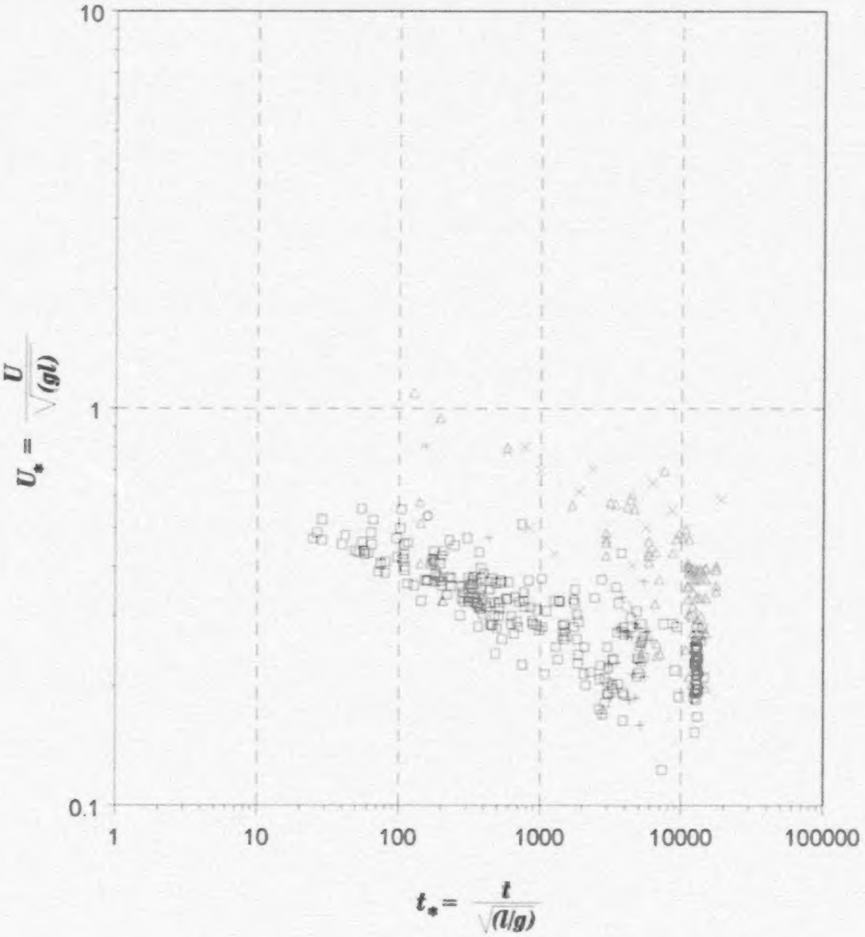


Figure E-2c. Processed endurance data for "Other" swim modes, unclassified or unknown swim mode data: dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are Acipenseridae; red triangles are Centrarchidae; green stars are Characidae; black circles are Cichlidae; turquoise diamonds Cyprinodontidae; blue crosses are Esocidae; red x's are Gasterosteidae; green squares are Moronidae; black triangles are Poeciliidae.*

Table E-2c. Fish count 2123, record count 402.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.184	0.134	0.023	1.32	1.297	170
T (C)	16.8	6.3	5	34	29	34
U (m/s)	0.435	0.202	0.126	1.8	1.674	197
t_e (s)	255	340	4	1797	1793	160
$t_{\Delta t}$ (s)	1089	619	10	1800	1790	8

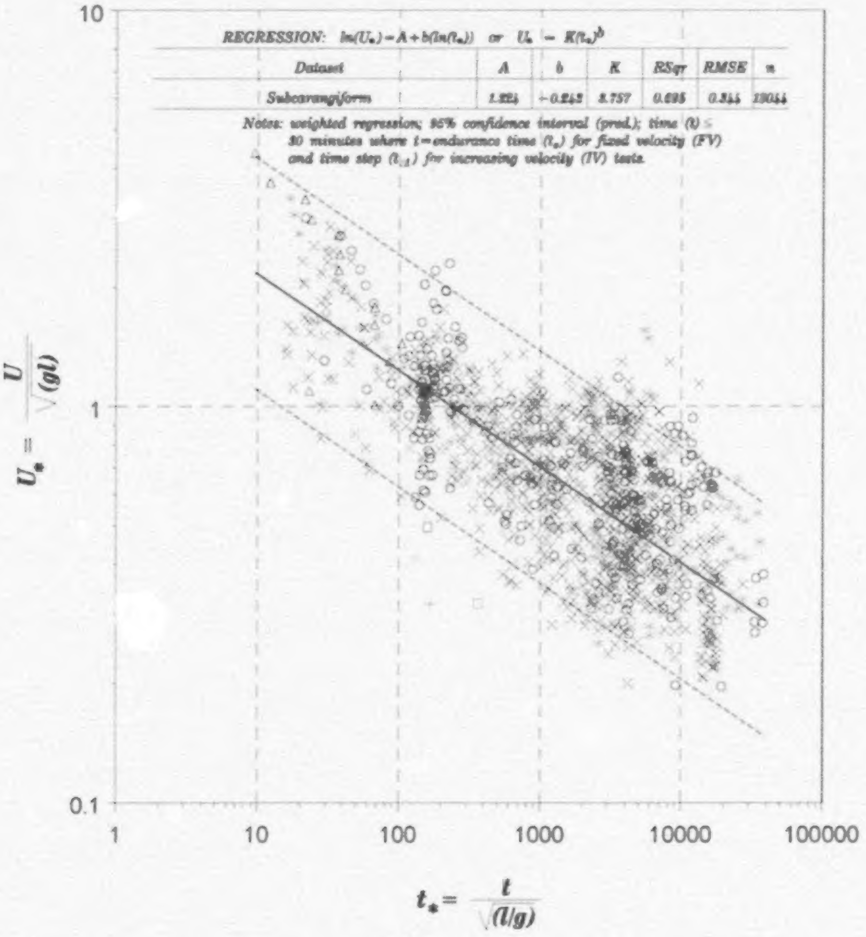


Figure E-2d. Processed endurance data for Subcarangiform swim mode: dimensionless swim speed (U) versus dimensionless time-to-fatigue (t*). Blue squares are Atherinidae; red triangles are Balitoridae; green stars are Catostomidae; black circles are Cyprinidae; turquoise diamonds are Cyprinodontidae; blue crosses are Hiodontidae; red x's are Ictaluridae; green squares are Lepisosteidae; black triangles are Moronidae; turquoise stars are Osmeridae; blue circles are Percidae; red diamonds are Plecoglossidae; green crosses are Poeciliidae; black x's are Salmonidae.*

Table E-2d. Data summary. Fish count 18044, record count 1362.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.195	0.192	0.021	0.927	0.906	597
T (C)	14.1	5.2	3.1	32.9	29.8	187
U (m/s)	1.182	1.267	0.11	9.45	9.34	737
t_e (s)	423	546	2	1800	1798	378
$t_{\Delta t}$ (s)	522	513	10	1800	1790	12

APPENDIX 1–SERIES F

Processed Endurance Data

Swim Speed (*U; m/s*) vs Time-to-Fatigue (*t; seconds*)

Swim Speed (*U/l; body lengths/second*) vs Time-to-Fatigue (*t; seconds*)

Dimensionless Swim Speed (U_*) vs Dimensionless Time-to-Fatigue (t_*)

Plotted by Data Group and Other Parameters (42 graphs)

- This series contains graphs of the various data groupings that were established based on an analysis of the dimensionless endurance data. The data groups consist of different fish species that showed similarities in swimming performance based on endurance test results collected from the literature. The analysis was based on endurance times of 30 minutes or less. Groups have been named based on the dominant species; however some groups do contain a large variety of species. The summary table (Table A2a) provides a detailed list of the species in each group. Graphs have been produced for the following groups:
    - Catfish and Sunfish Group
    - Clupeidae (Herring) Group
    - Eel Group
    - Pike Group
    - Salmon and Walleye Group
    - Sturgeon Group
- The following graphs were produced for each data group:
    - Time to Fatigue (t; sec) vs Swim Speed (U; m/s) by Family
    - Time to Fatigue (t; sec) vs Swim Speed (U/l; body lengths per second) by Family
    - Dimensionless Time to Fatigue (t_*) vs Dimensionless Swim Speed (U_*) by: Family; Test Apparatus and Method; Fish Length; and Water Temperature
- These graphs were produced to provide a more detailed overview of the groups in terms of the use of the different variables for endurance and additional information about the underlying data. The graphs with the variations in swim speed (m/s; body lengths per second and dimensionless) and time-to-fatigue (second and dimensionless) illustrate how changes in these variables can reshape and refine the data to produce more effective estimates of performance. The different dimensionless graphs provide a quick overview of the data composition of the different groups in the terms of test methods, fish sizes and water temperature.
- Further details are provided in the report.

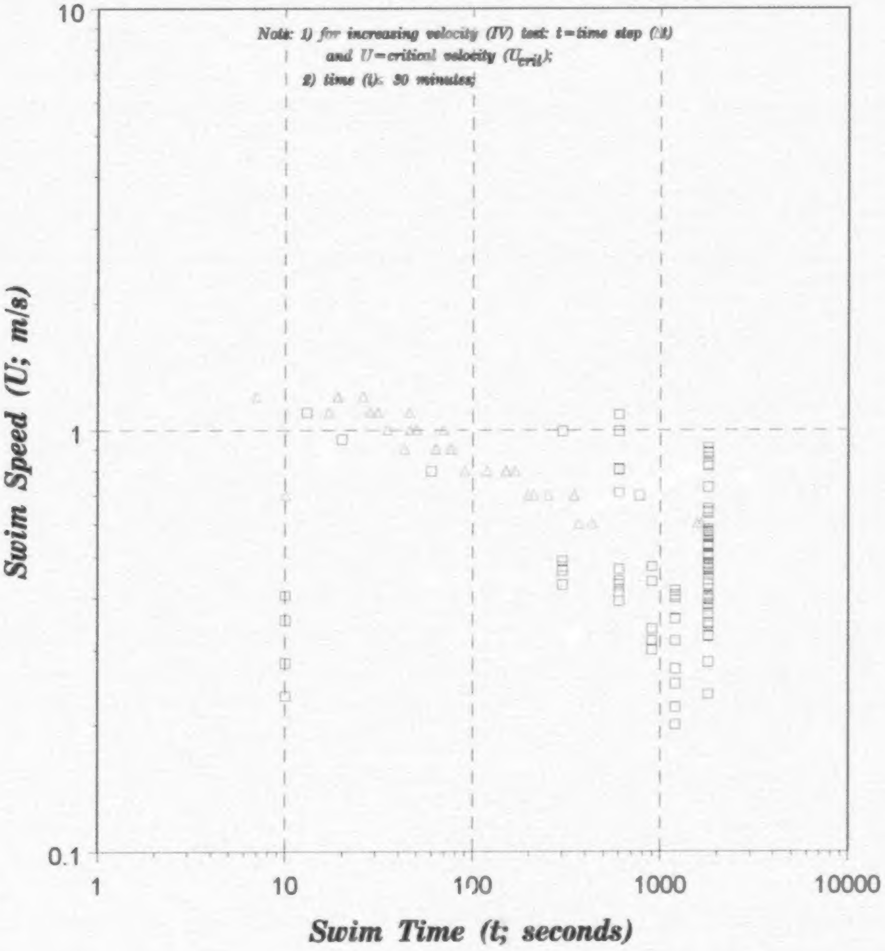


Figure F1-a. Processed data for the Catfish and Sunfish Group; time-to-fatigue verus swim speed (m/s). Blue squares are Centrachidae; red triangles are Ictaluridae.

Table F1-a. Data summary. Fish count 1282, record count 115.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.179	0.07	0.032	0.424	0.392	40
T (C)	20.7	5.9	5	34	29	27
U (m/s)	0.627	0.271	0.2	1.2	1	81
t_e (s)	208	375	7	1656	1649	30
$t_{\Delta t}$ (s)	1285	625	10	1800	1790	6

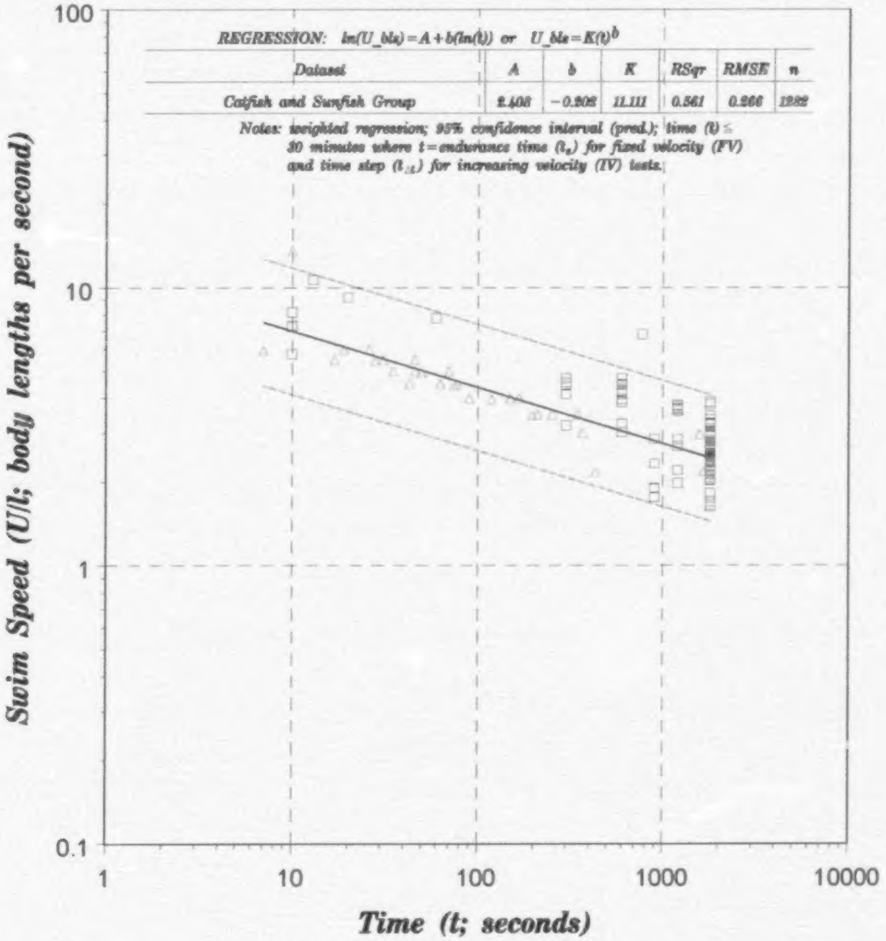
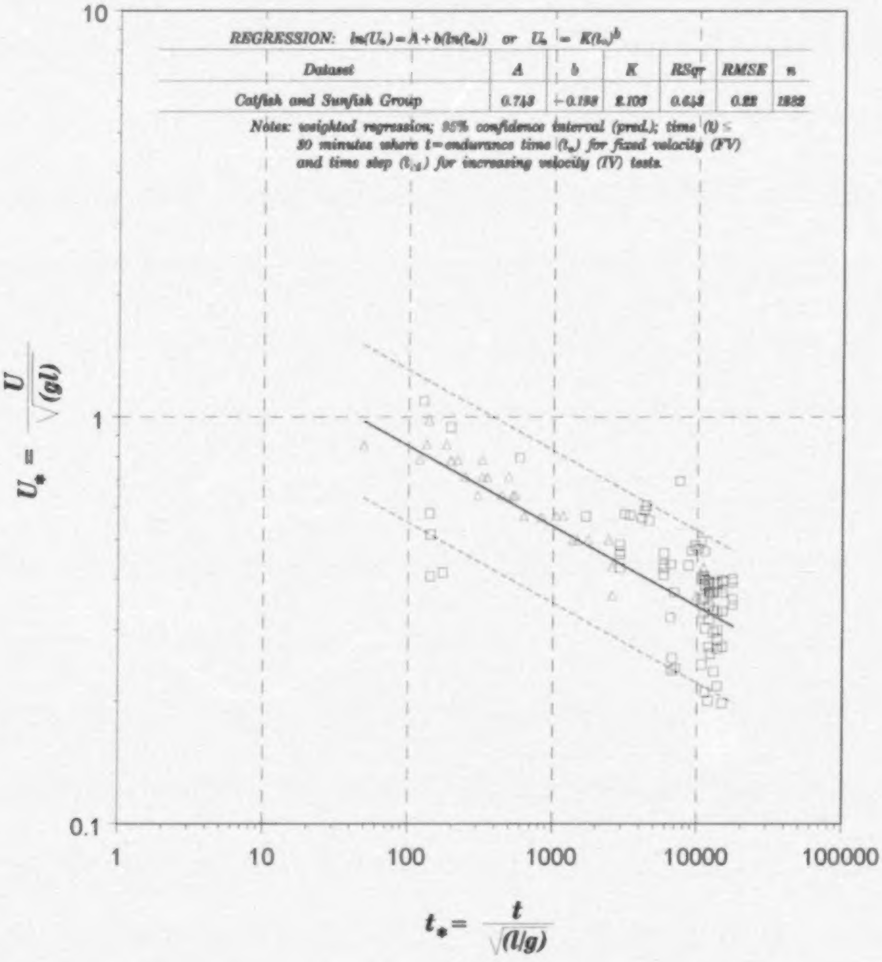


Figure F1-b Processed data for the Catfish and Sunfish Group; time-to-fatigue verus swim speed (body lengths per second). Blue squares are Centrachidae; red triangles are Ictaluridae.

Table F1-b. Data summary. Fish count 1282, record count 115.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.184	0.077	0.032	0.424	0.392	40
T (C)	19.4	5.6	5	34	29	27
U (m/s)	0.6	0.27	0.2	1.2	1	81
t_e (s)	488	611	7	1656	1649	30
$t_{\Delta t}$ (s)	1082	554	10	1800	1790	6



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Catfish and Sunfish Group	0.743	-0.198	2.102	0.643	0.22	1282

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure F1-c. Processed data for the Catfish and Sunfish Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Centrachidae; red triangles are Ictaluridae.

Table F1-c. Data summary. Fish count 1282, record count 115.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.184	0.077	0.032	0.424	0.392	40
T (C)	19.4	5.6	5	34	29	27
U (m/s)	0.6	0.27	0.2	1.2	1	81
t_e (s)	488	611	7	1656	1649	30
$t_{\Delta t}$ (s)	1082	554	10	1800	1790	6

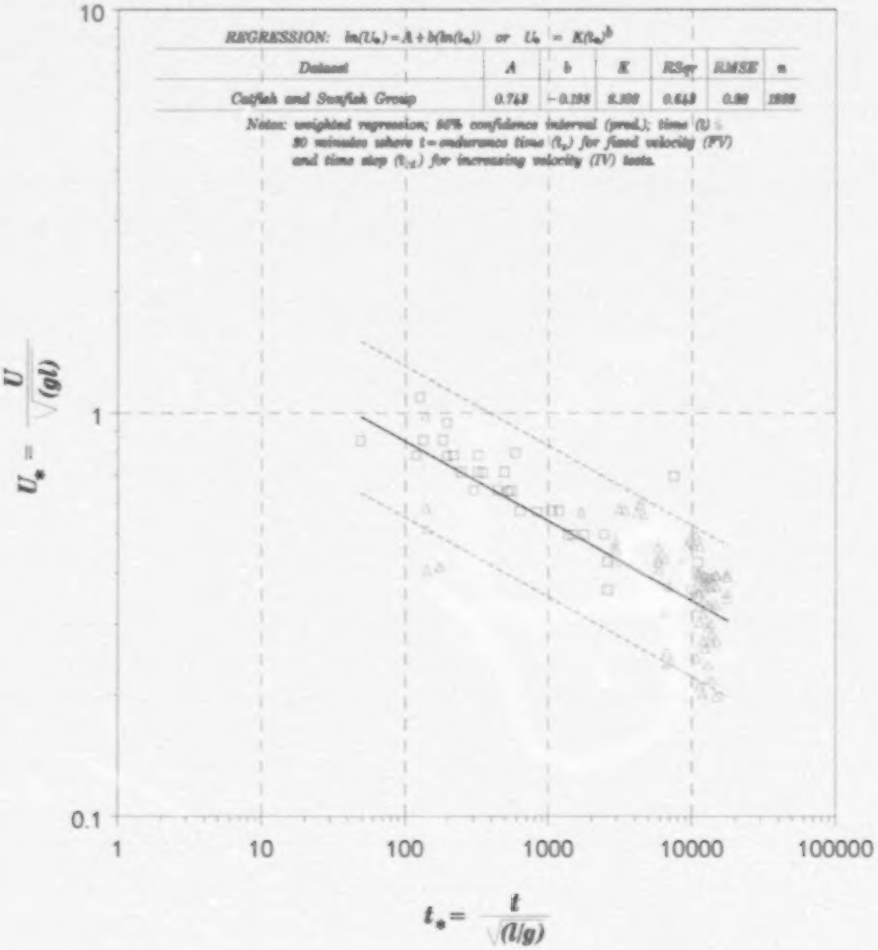


Figure F1-d. Processed data for the Catfish and Sunfish Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are data from swim tunnels with fixed velocity (FV); red triangles are data from swim tunnels with increasing velocity (IV).

Table F1-d. Data summary. Fish count 1282, record count 115.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.184	0.077	0.032	0.424	0.392	40
T (C)	19.4	5.6	5	34	29	27
U (m/s)	0.6	0.27	0.2	1.2	1	81
t_e (s)	488	611	7	1656	1649	30
$t_{\Delta t}$ (s)	1082	554	10	1800	1790	6

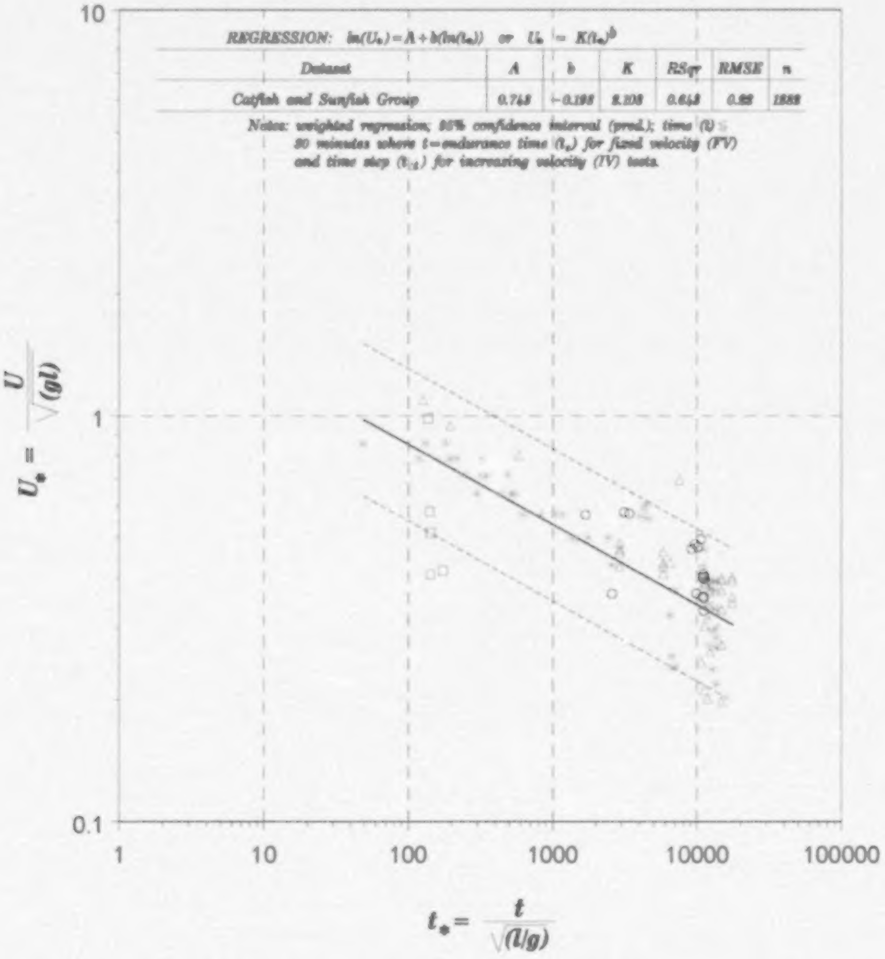


Figure F1-e. Processed data for the Catfish and Sunfish Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are fishes of 0.025-0.075 m length; red triangles are fishes of 0.075-0.15 m length; green stars are fishes of 0.15-0.25 m length; black circles are fishes of 0.25-0.40 m length; turquoise diamonds are fishes of 0.40-0.65 m length.

Table F1-e. Data summary. Fish count 1282, record count 115.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.184	0.077	0.032	0.424	0.392	40
T (C)	19.4	5.6	5	34	29	27
U (m/s)	0.6	0.27	0.2	1.2	1	81
t_e (s)	488	611	7	1656	1649	30
$t_{\Delta t}$ (s)	1082	554	10	1800	1790	6

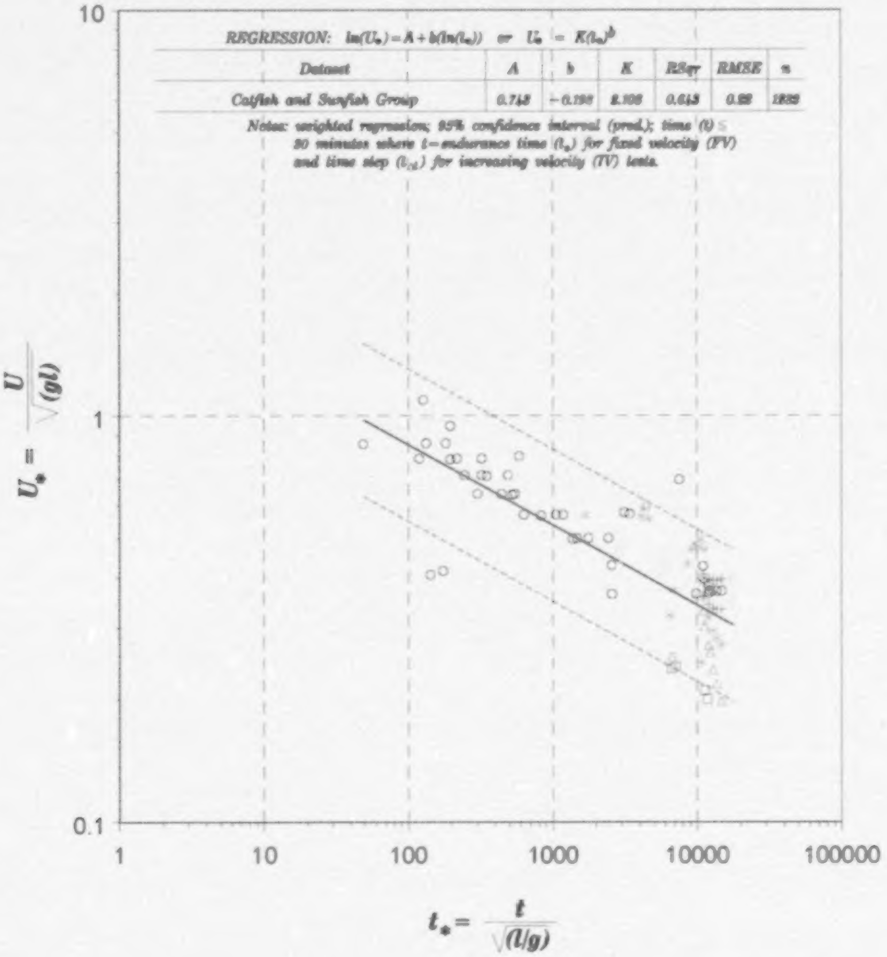


Figure F1-f. Processed data for the Catfish and Sunfish Group; time-to-fatigue verus swim speed (m/s). Blue squares are data from 5-10°C, red triangles are data from 10-15°C; green stars are data from 15-20°C; black circles are data from 20-25°C; turquoise diamonds are data from 25-30°C; blue crosses are data from 30-35°C.

Table F1-f. Data summary. Fish count 1282, record count 115.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.184	0.077	0.032	0.424	0.392	40
T (C)	19.4	5.6	5	34	29	27
U (m/s)	0.6	0.27	0.2	1.2	1	81
t_e (s)	488	611	7	1656	1649	30
$t_{\Delta t}$ (s)	1082	554	10	1800	1790	6

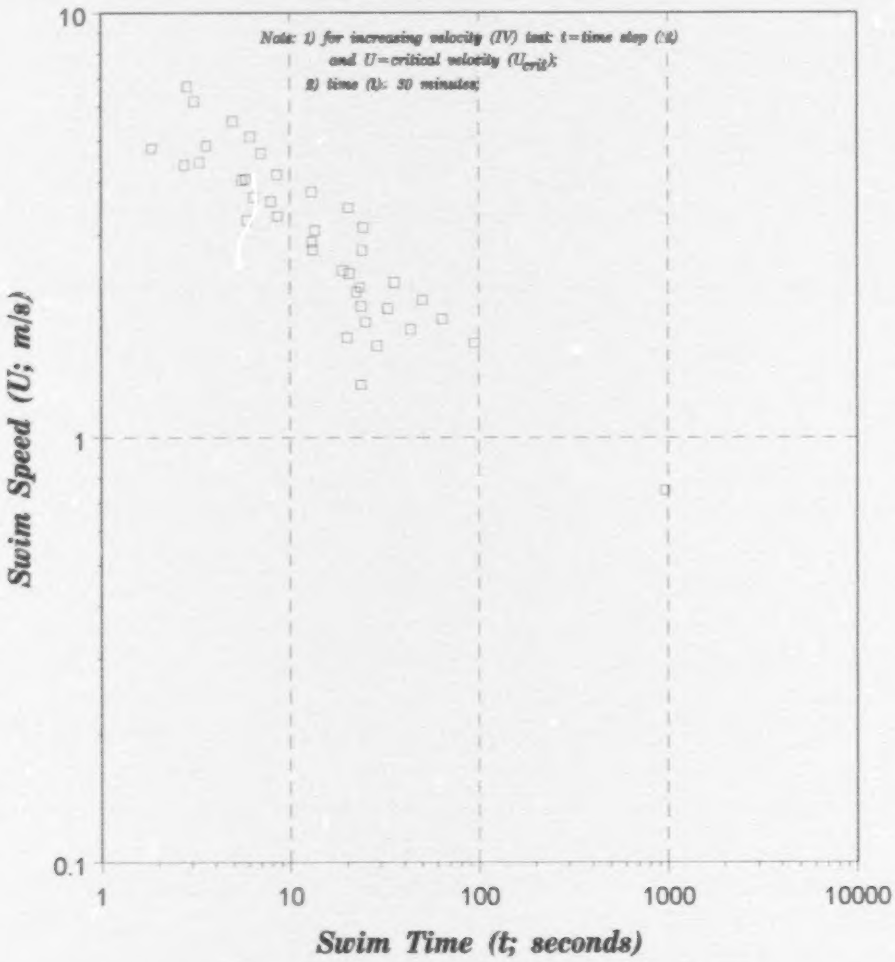


Figure F2-a. Processed data for the Clupeidae (Herring) Group; time-to-fatigue verus swim speed (m/s). Blue squares are Clupeidae.

Table F2-a. Data summary. Fish count 592, record count 39.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.302	0.091	0.219	0.418	0.199	9
T (C)	15.3	3.6	10.4	20.4	10	5
U (m/s)	3.211	1.398	0.75	6.71	5.96	39
t_e (s)	44	154	2	960	958	38
$t_{\Delta t}$ (s)	20	·	20	20	0	1

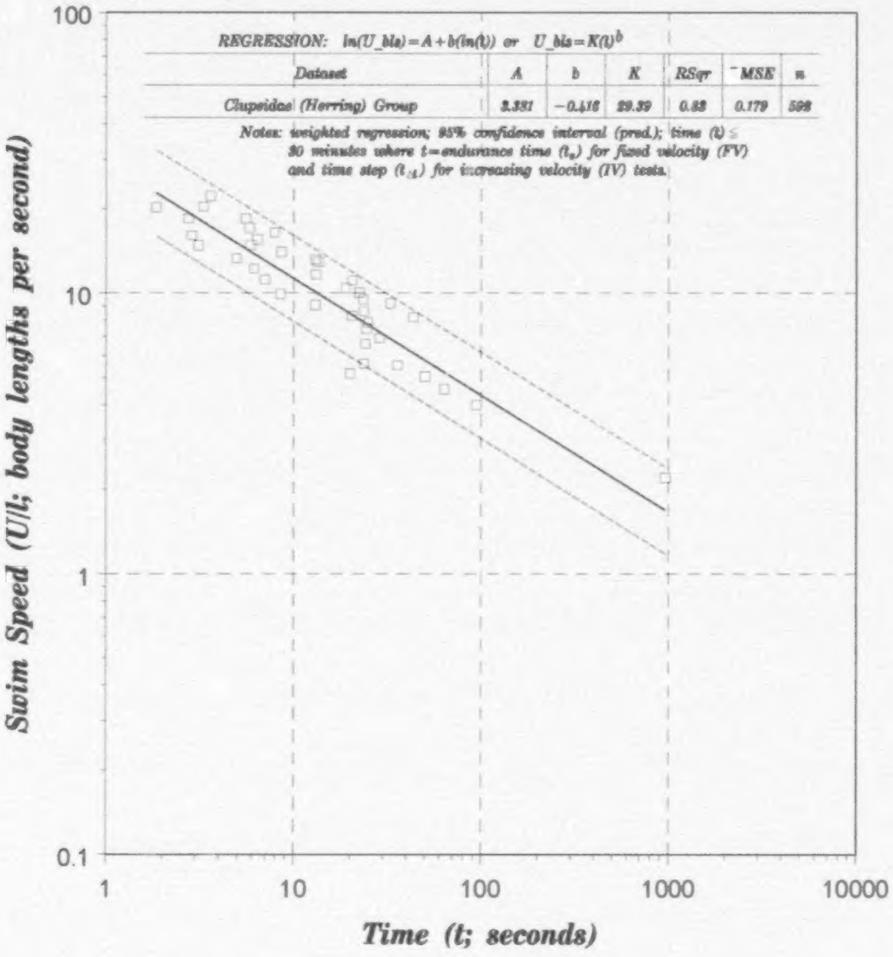


Figure F2-b Processed data for the Clupeidae (Herring) Group; time-to-fatigue verus swim speed (body lengths per second). Blue squares are Clupeidae.

Table F2-b. Data summary. Fish count 592, record count 39.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.328	0.092	0.219	0.418	0.199	9
T (C)	15.4	3.7	10.4	20.4	10	5
U (m/s)	3.452	1.279	0.75	6.71	5.96	39
t_e (s)	26	89	2	960	958	38
$t_{\Delta t}$ (s)	20	0	20	20	0	1

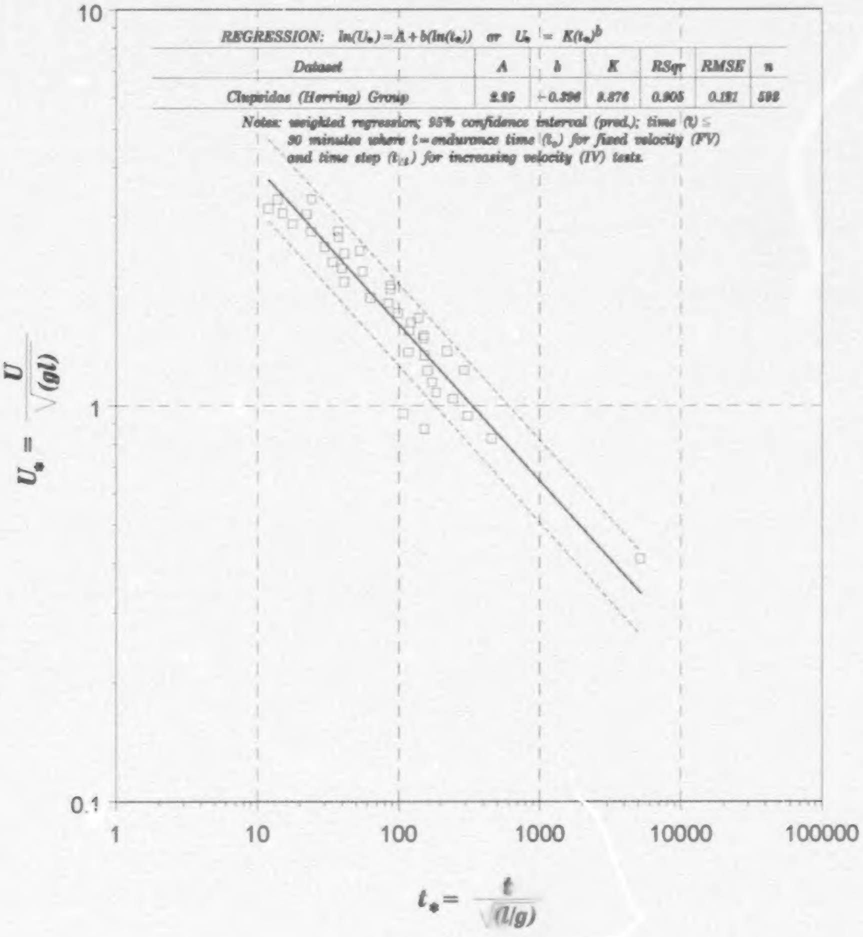


Figure F2-c. Processed data for the Clupeidae (Herring) Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Clupeidae.

Table F2-c. Data summary. Fish count 592, record count 39.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.328	0.092	0.219	0.418	0.199	9
T (C)	15.4	3.7	10.4	20.4	10	5
U (m/s)	3.452	1.279	0.75	6.71	5.96	39
t_e (s)	26	89	2	960	958	38
$t_{\Delta t}$ (s)	20	0	20	20	0	1

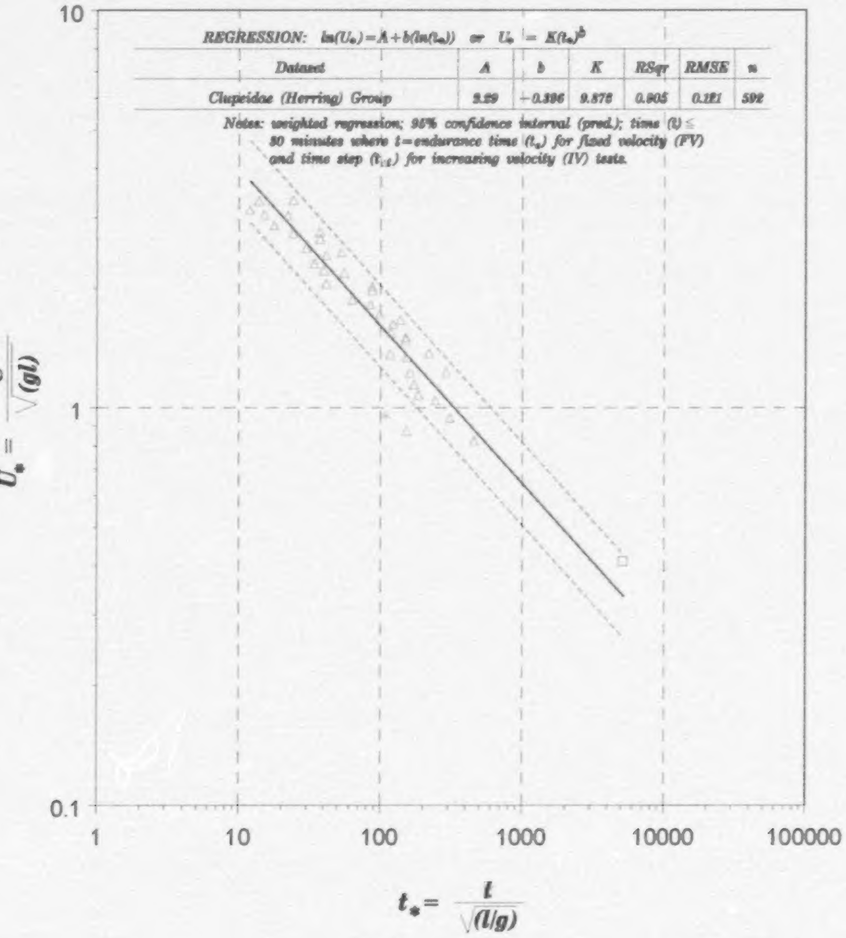


Figure F2-d. Processed data for the Clupeidae (Herring) Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are data from open channel (OC) flume tanks (constrained); red triangles are data from OC flume tanks; green stars are swim tunnels with increasing velocity (IV).

Table F2-d. Data summary. Fish count 592, record count 39.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.328	0.092	0.219	0.418	0.199	9
T (C)	15.4	3.7	10.4	20.4	10	5
U (m/s)	3.452	1.279	0.75	6.71	5.96	39
t_e (s)	26	89	2	960	958	38
$t_{\Delta t}$ (s)	20	0	20	20	0	1

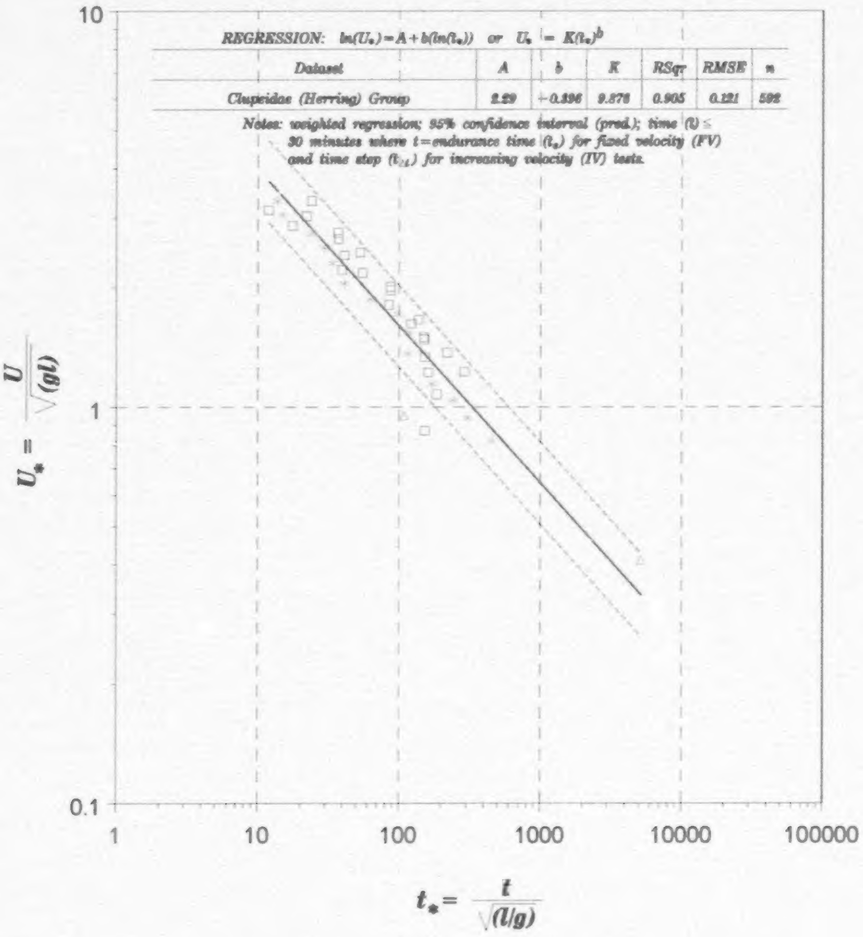


Figure F2-e. Processed data for the Clupeidae (Herring) Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are fishes of 0.15-0.25 m length; red triangles are fishes of 0.25-0.40 m length; green stars are fishes of 0.40-0.65 m length.

Table F2-e. Data summary. Fish count 592, record count 39.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.328	0.092	0.219	0.418	0.199	9
T (C)	15.4	3.7	10.4	20.4	10	5
U (m/s)	3.452	1.279	0.75	6.71	5.96	39
t_e (s)	26	89	2	960	958	38
$t_{\Delta t}$ (s)	20	0	20	20	0	1

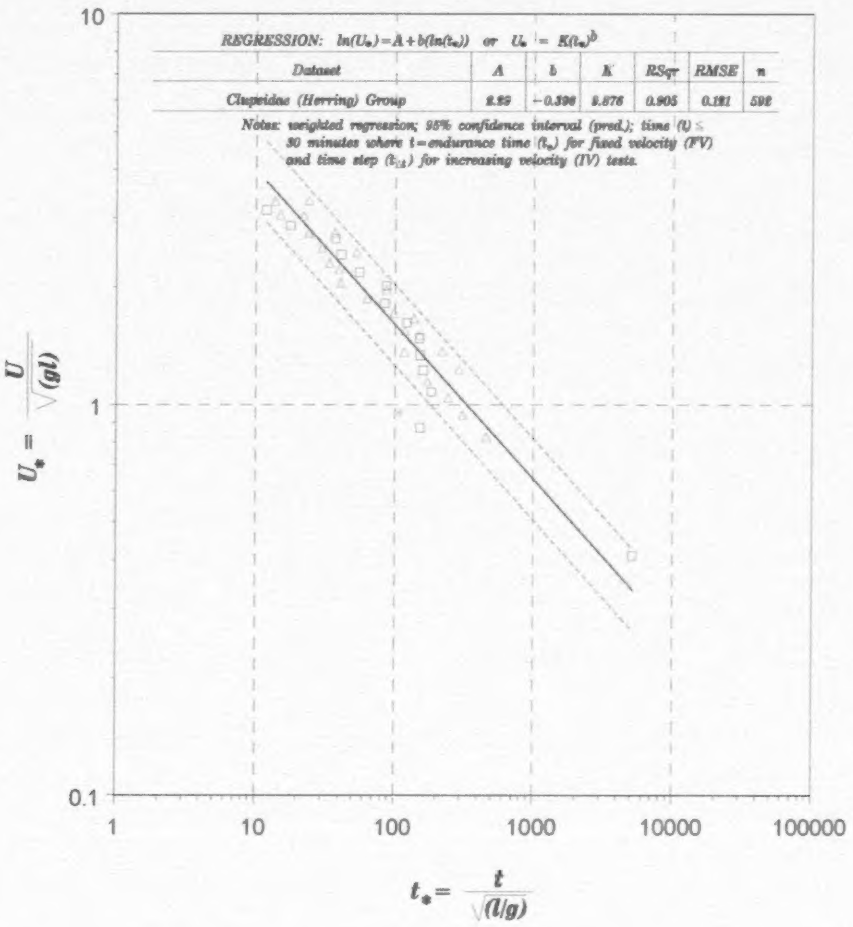


Figure F2-f. Processed data for the Clupeidae (Herring) Group; time-to-fatigue verus swim speed (m/s). Blue squares are data from 10-15°C; red triangles are data from15-20°C; green stars are data from 20-25°C.

Table F2-f. Data summary. Fish count 592, record count 39.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.328	0.092	0.219	0.418	0.199	9
T (C)	15.4	3.7	10.4	20.4	10	5
U (m/s)	3.452	1.279	0.75	6.71	5.96	39
t_e (s)	26	89	2	960	958	38
$t_{\Delta t}$ (s)	20	0	20	20	0	1

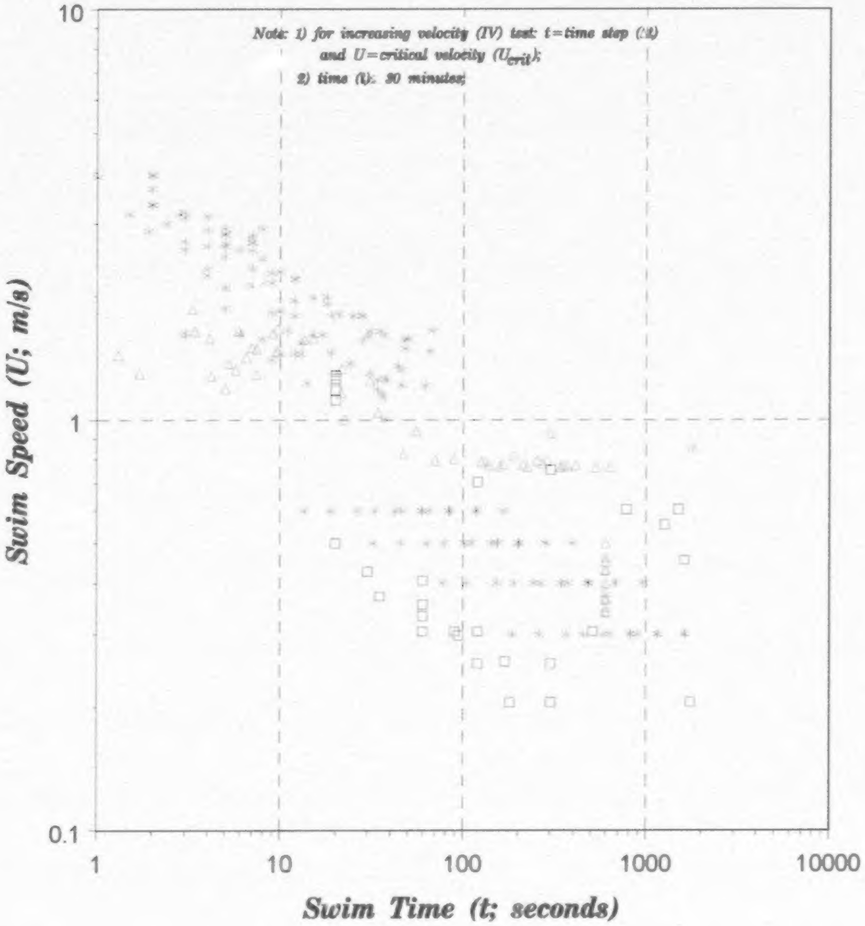


Figure F3-a. Processed data for the Eel Group; time-to-fatigue verus swim speed (m/s). Blue squares are Anguillidae; red triangles are Gadidae; green stars are Petromyzontidae.

Table F3-a. Data summary. Fish count 1747, record count 242.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.356	0.151	0.072	0.641	0.569	116
T (C)	13.8	4.6	5	23.5	18.5	70
U (m/s)	1.231	0.886	0.205	3.961	3.756	160
t_e (s)	170	319	0	1740	1740	157
$t_{\Delta t}$ (s)	480	421	20	1800	1780	3

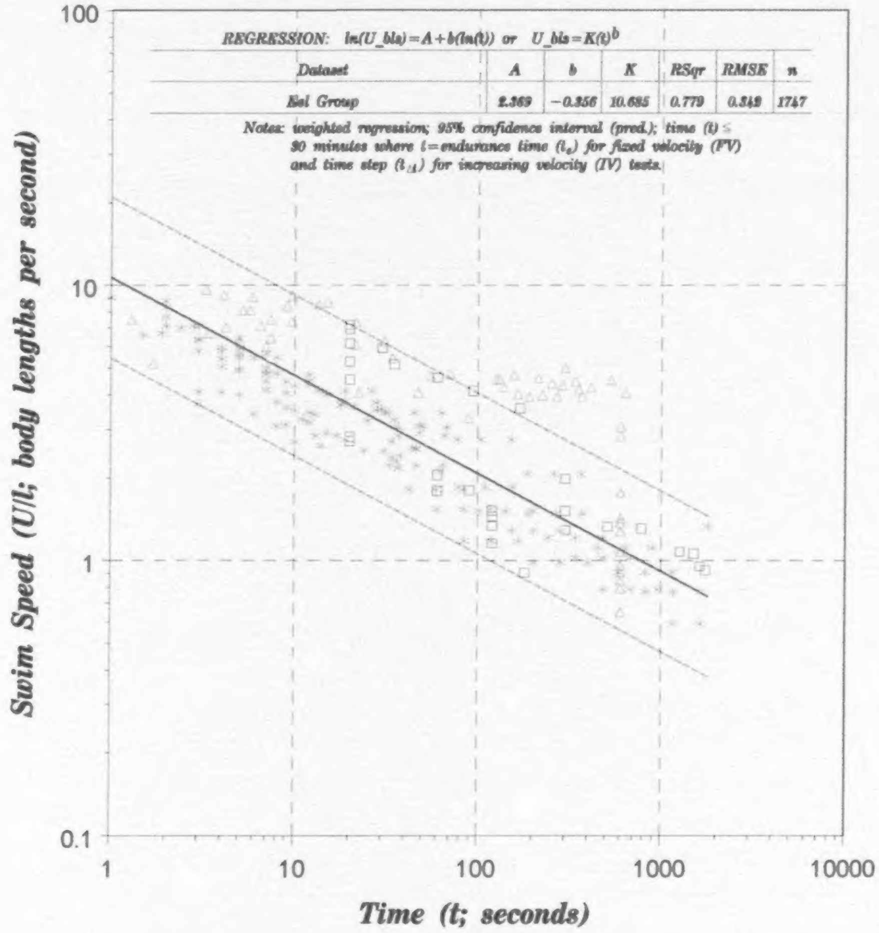
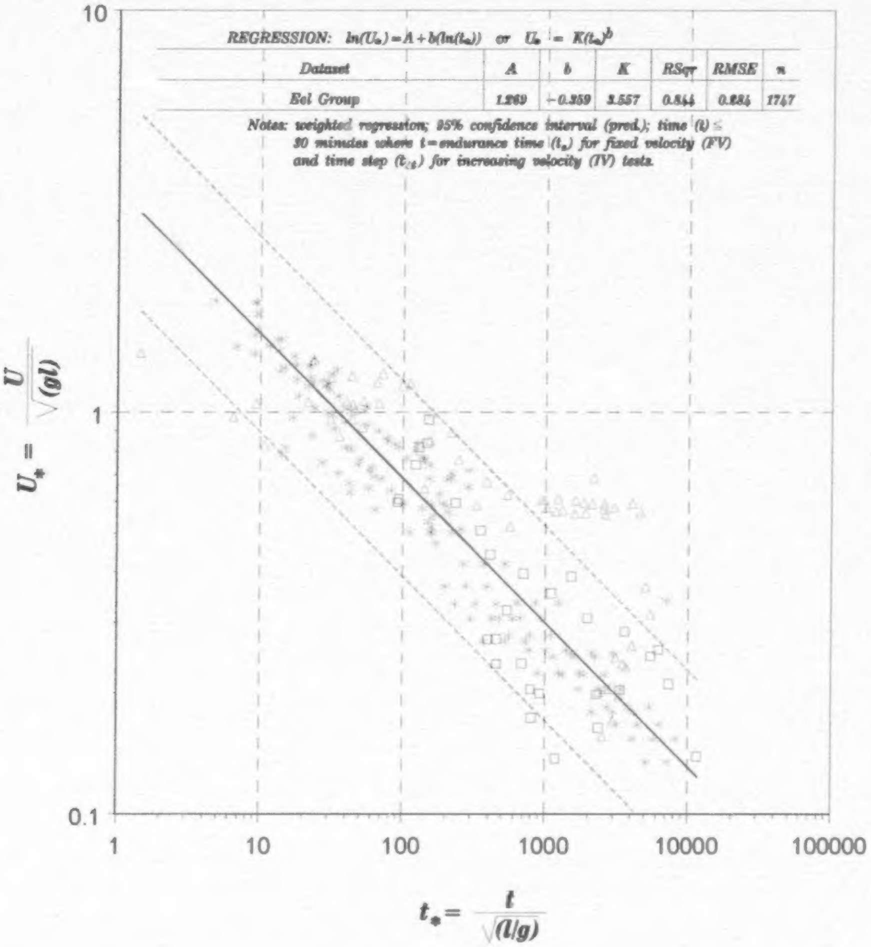


Figure F3-b. Processed data for the Eel Group; time-to-fatigue verus swim speed (body lengths per second). Blue squares are Anguillidae; red triangles are Gadidae; green stars are Petromyzontidae.

Table F3-b. Data summary. Fish count 1747, record count 242.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.343	0.149	0.072	0.641	0.569	116
T (C)	13.5	4.7	5	23.5	18.5	70
U (m/s)	1.05	0.921	0.205	3.961	3.756	160
t_e (s)	234	366	0	1740	1740	157
$t_{\Delta t}$ (s)	225	471	20	1800	1780	3



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Eel Group	1.269	-0.259	3.557	0.844	0.284	1747

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure F3-c. Processed data for the Eel Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Anguillidae; red triangles are Gadidae; green stars are Petromyzontidae.

Table F3-c. Data summary. Fish count 1747, record count 242.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.343	0.149	0.072	0.641	0.569	116
T (C)	13.5	4.7	5	23.5	18.5	70
U (m/s)	1.05	0.921	0.205	3.961	3.756	160
t_e (s)	234	366	0	1740	1740	157
$t_{\Delta t}$ (s)	225	471	20	1800	1780	3

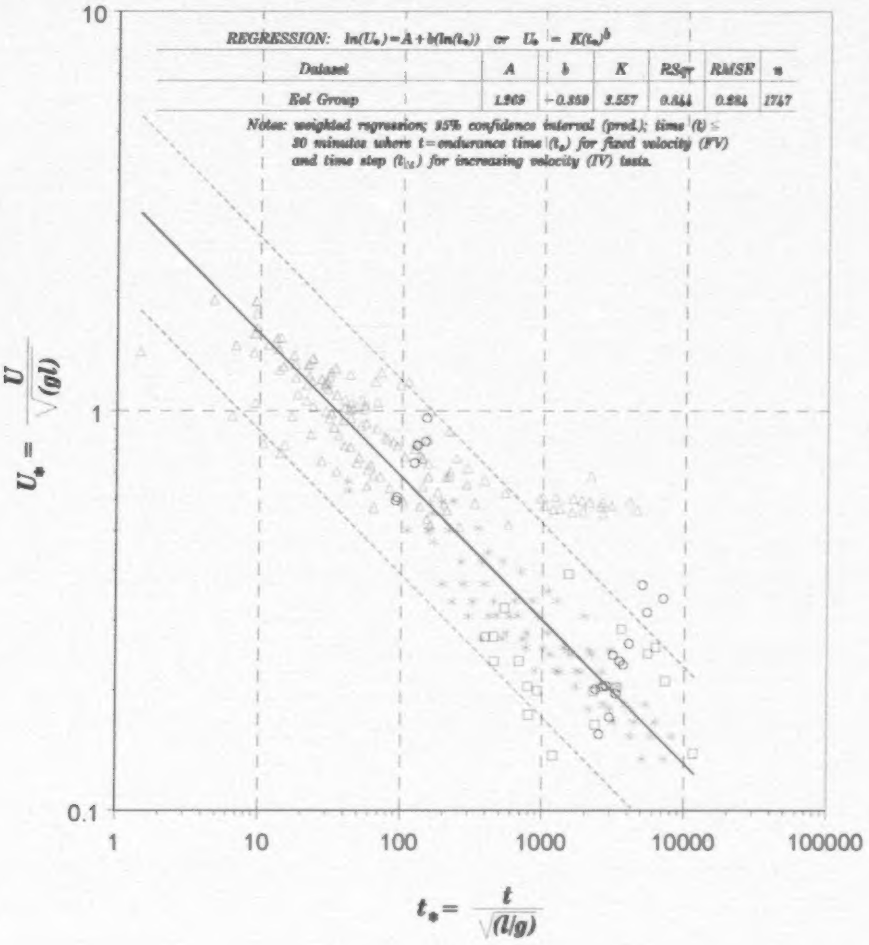


Figure F3-d. Processed data for the Eel Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are data from open channel flume tanks (constrained); red triangles are data from OC flume channels; green stars are data from fixed velocity (FV) swim tunnels; black circles are increasing velocity (IV) swim tunnels.

Table F3-d. Data summary. Fish count 1747, record count 242.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.343	0.149	0.072	0.641	0.569	116
T (C)	13.5	4.7	5	23.5	18.5	70
U (m/s)	1.05	0.921	0.205	3.961	3.756	160
t_e (s)	234	366	0	1740	1740	157
$t_{\Delta t}$ (s)	225	471	20	1800	1780	3

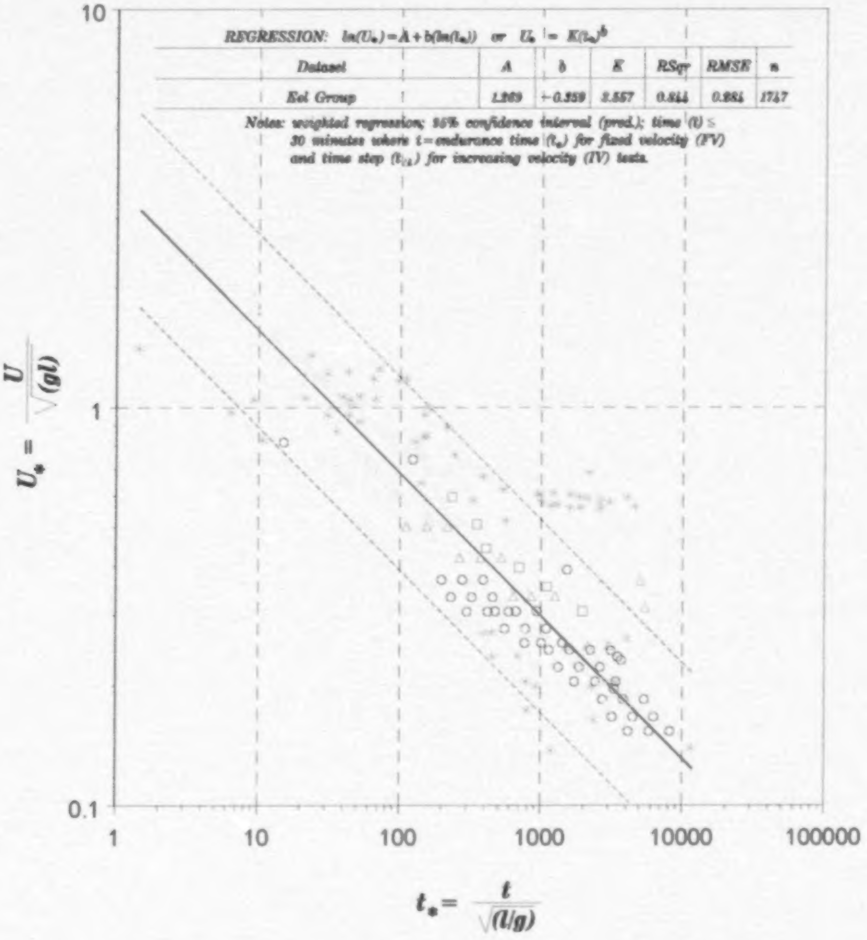


Figure F3-e. Processed data for the Eel Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are fishes of 0.025-0.075 m length; red triangles are fishes of 0.075-0.15 m length; green stars are fishes of 0.15-0.25 m length; black circles are fishes of 0.25-0.40 m length; turquoise diamonds are fishes of 0.40-0.65 m length.

Table F3-e. Data summary. Fish count 1747, record count 242.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.343	0.149	0.072	0.641	0.569	116
T (C)	13.5	4.7	5	23.5	18.5	70
U (m/s)	1.05	0.921	0.205	3.961	3.756	160
t_e (s)	234	366	0	1740	1740	157
$t_{\Delta t}$ (s)	225	471	20	1800	1780	3

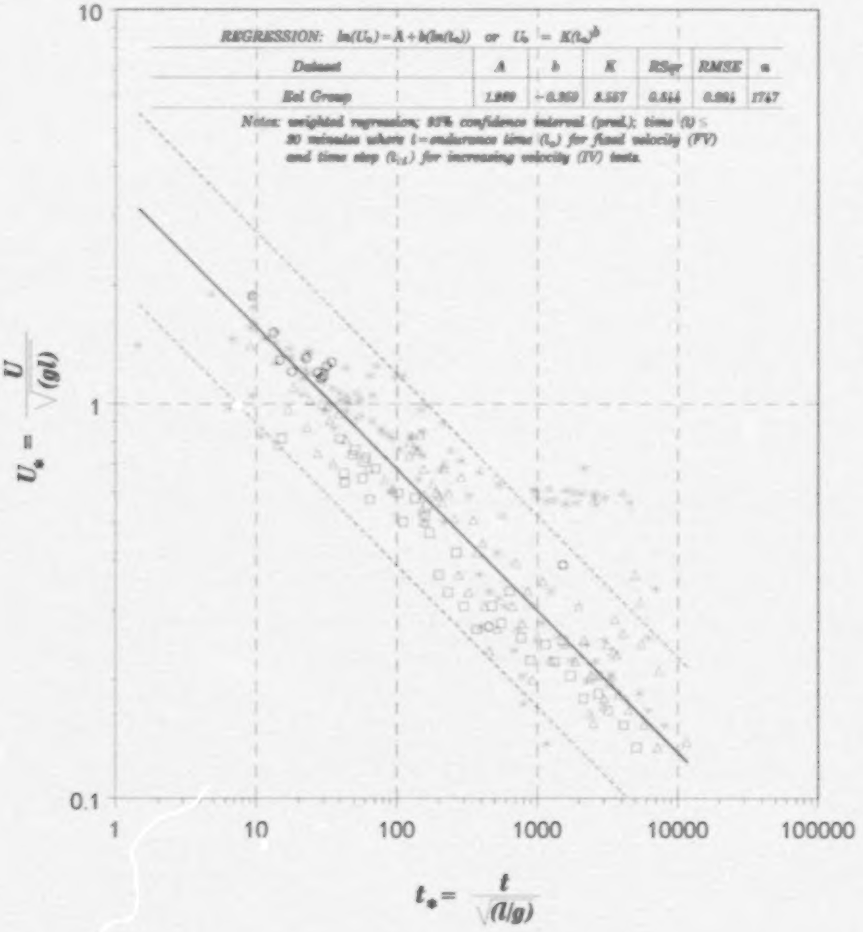


Figure F3-f. Processed data for the Eel Group; time-to-fatigue verus swim speed (m/s). Blue squares are data from 5-10°C; red triangles are data from 10-15°C; green stars are data from 15-20°C; black circles are data from 20-25°C.

Table F3-f. Data summary. Fish count 1747, record count 242.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.343	0.149	0.072	0.641	0.569	116
T (C)	13.5	4.7	5	23.5	18.5	70
U (m/s)	1.05	0.921	0.205	3.961	3.756	160
t_e (s)	234	366	0	1740	1740	157
$t_{\Delta t}$ (s)	225	471	20	1800	1780	3

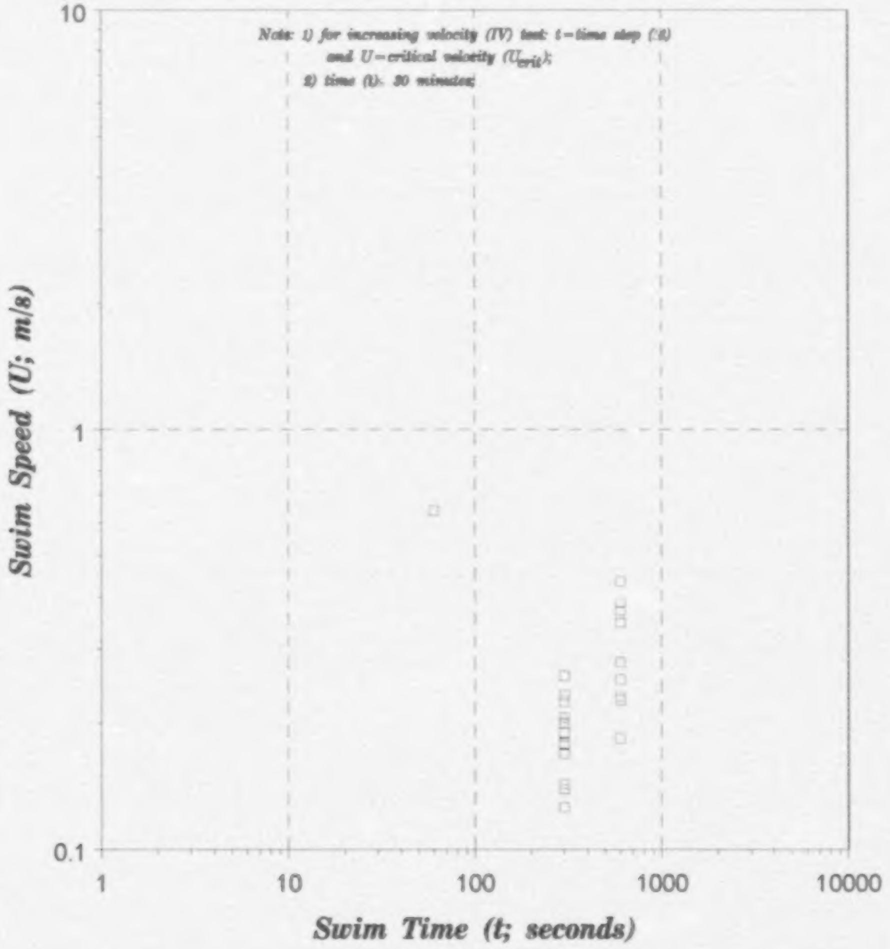


Figure F4-a. Processed data for the Pike Group; time-to-fatigue verus swim speed (m/s). Blue squares are Esocidae.

Table F4-a. Data summary. Fish count 138, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.122	0.124	0.024	0.48	0.456	26
T (C)	16.8	3.8	12	25	13	3
U (m/s)	0.241	0.115	0.126	0.642	0.516	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	395	159	60	600	540	3

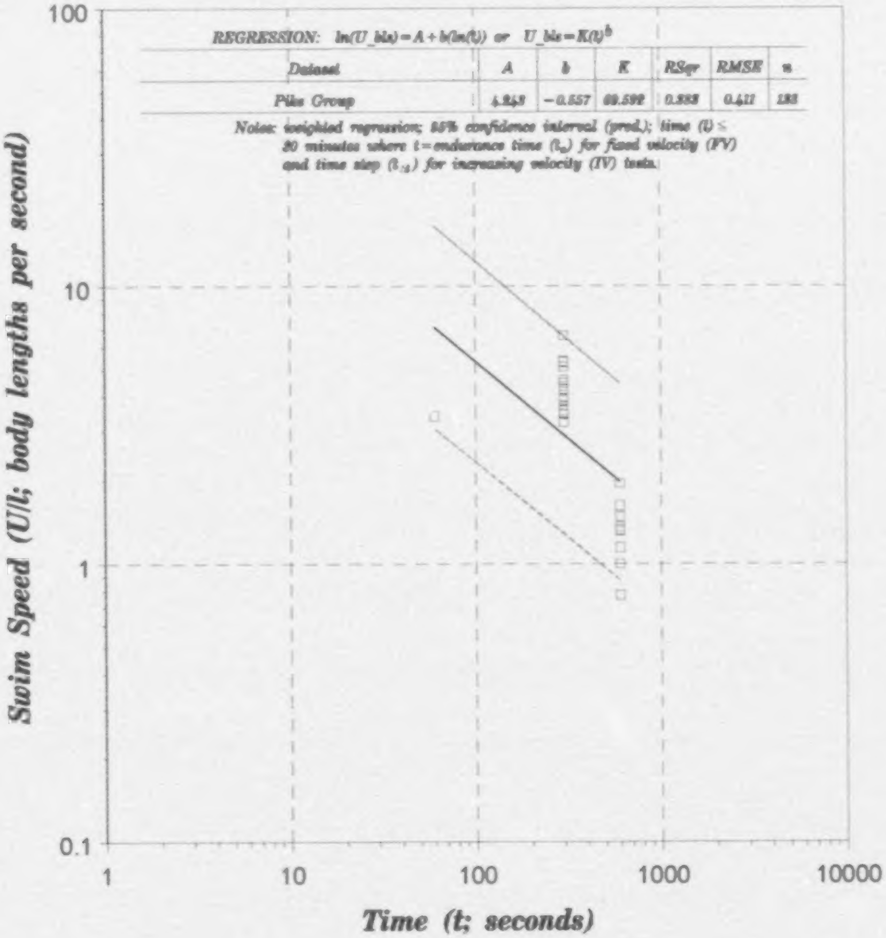
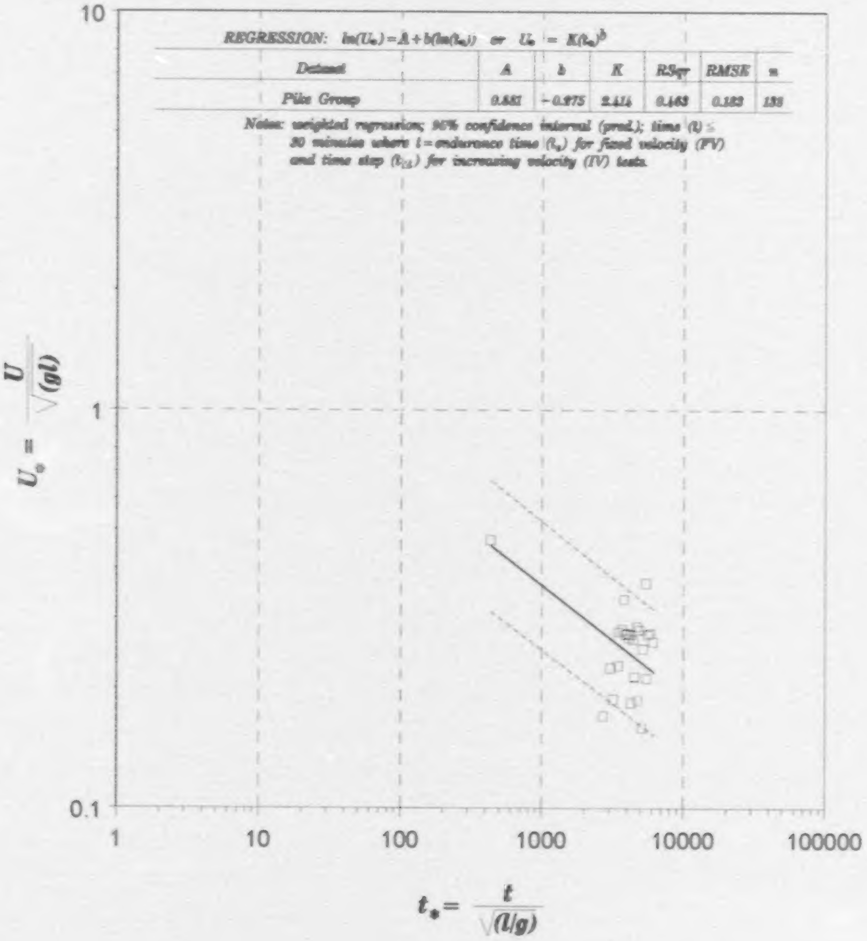


Figure F4-b Processed data for the Pike Group; time-to-fatigue verus swim speed (body lengths per second). Blue squares are Esocidae.

Table F4-b. Data summary. Fish count 138, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.114	0.094	0.024	0.48	0.456	26
T (C)	17.2	3.9	12	25	13	3
U (m/s)	0.252	0.125	0.126	0.642	0.516	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	380	165	60	600	540	3



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Pike Group	0.881	−0.975	2.414	0.463	0.183	138

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure F4-c. Processed data for the Pike Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Esocidae.

Table F4-c. Data summary. Fish count 138, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.114	0.094	0.024	0.48	0.456	26
T (C)	17.2	3.9	12	25	13	3
U (m/s)	0.252	0.125	0.126	0.642	0.516	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	380	165	60	600	540	3

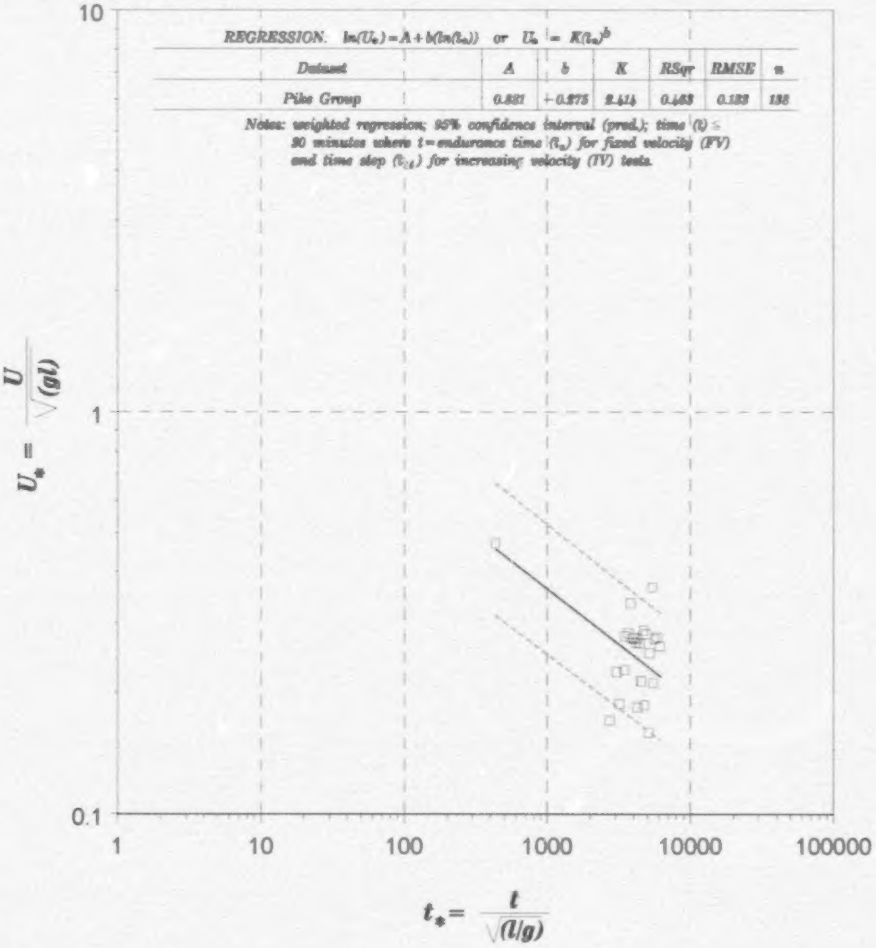


Figure F4-d. Processed data for the Pike Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are data from swim tunnels with increasing velocity (IV).

Table F4-d. Data summary. Fish count 138, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.114	0.094	0.024	0.48	0.456	26
T (C)	17.2	3.9	12	25	13	3
U (m/s)	0.252	0.125	0.126	0.642	0.516	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	380	165	60	600	540	3

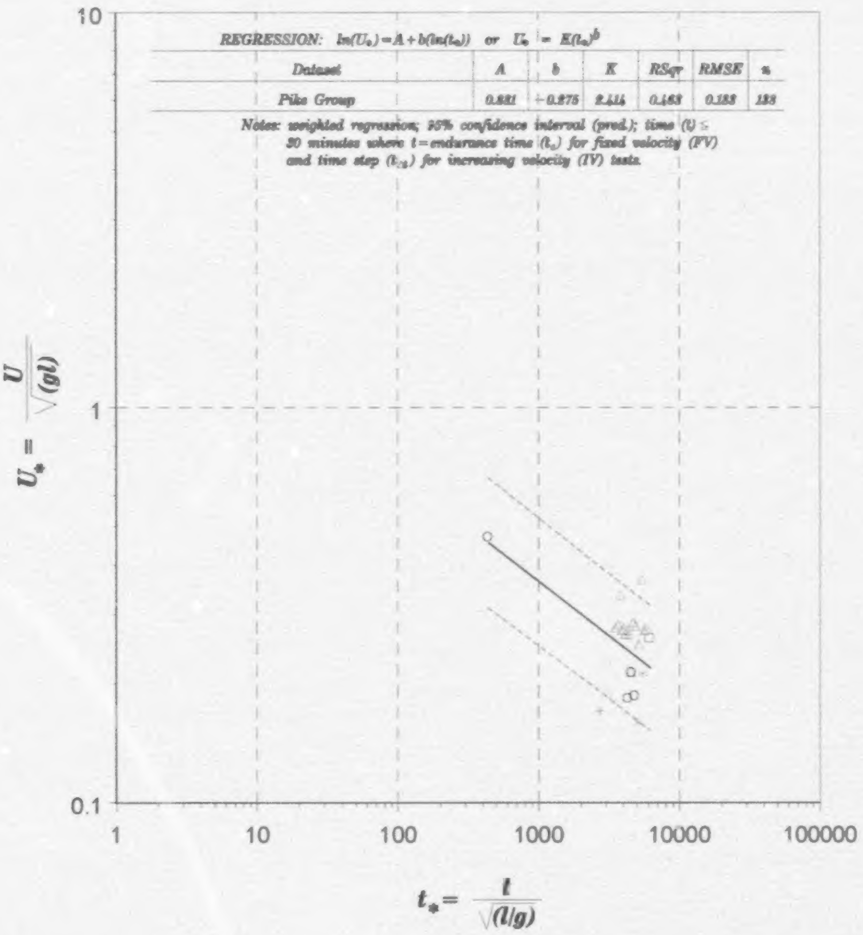


Figure F4-e. Processed data for the Pike Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are fishes less than 0.025 m length; red triangles are fishes of 0.025-0.075 m length; green stars are fishes of 0.075-0.15 m length; black circles are fishes of 0.15-0.25 m length; turquoise diamonds are fishes of 0.25-0.40 m length; blue crosses are fishes of 0.40-0.65 m length.

Table F4-e. Data summary. Fish count 138, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.114	0.094	0.024	0.48	0.456	26
T (C)	17.2	3.9	12	25	13	3
U (m/s)	0.252	0.125	0.126	0.642	0.516	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	380	165	60	600	540	3

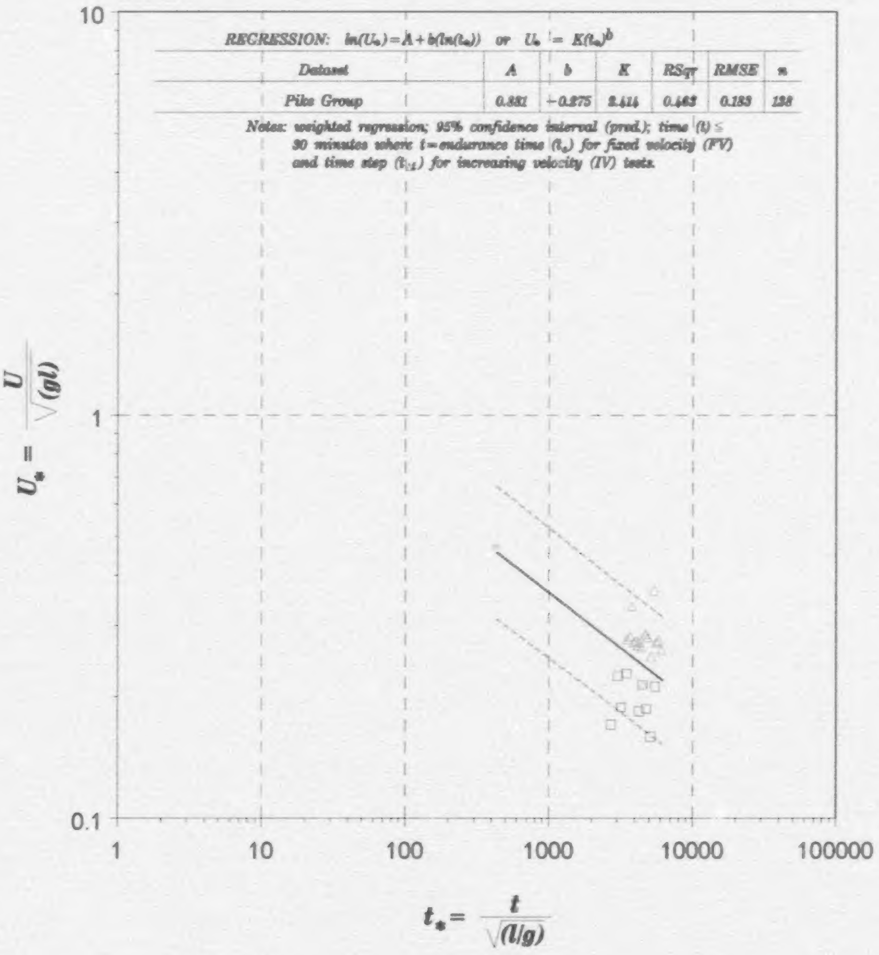


Figure F4-f. Processed data for the Pike Group; time-to-fatigue verus swim speed (m/s). Blue squares are data from 10-15°C; red triangles are data from 15-20°C; green stars are data from 25-30°C.

Table F4-f. Data summary. Fish count 138, record count 26.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.114	0.094	0.024	0.48	0.456	26
T (C)	17.2	3.9	12	25	13	3
U (m/s)	0.252	0.125	0.126	0.642	0.516	24
t_e (s)	.	.	.	.	.	0
$t_{\Delta t}$ (s)	380	165	60	600	540	3

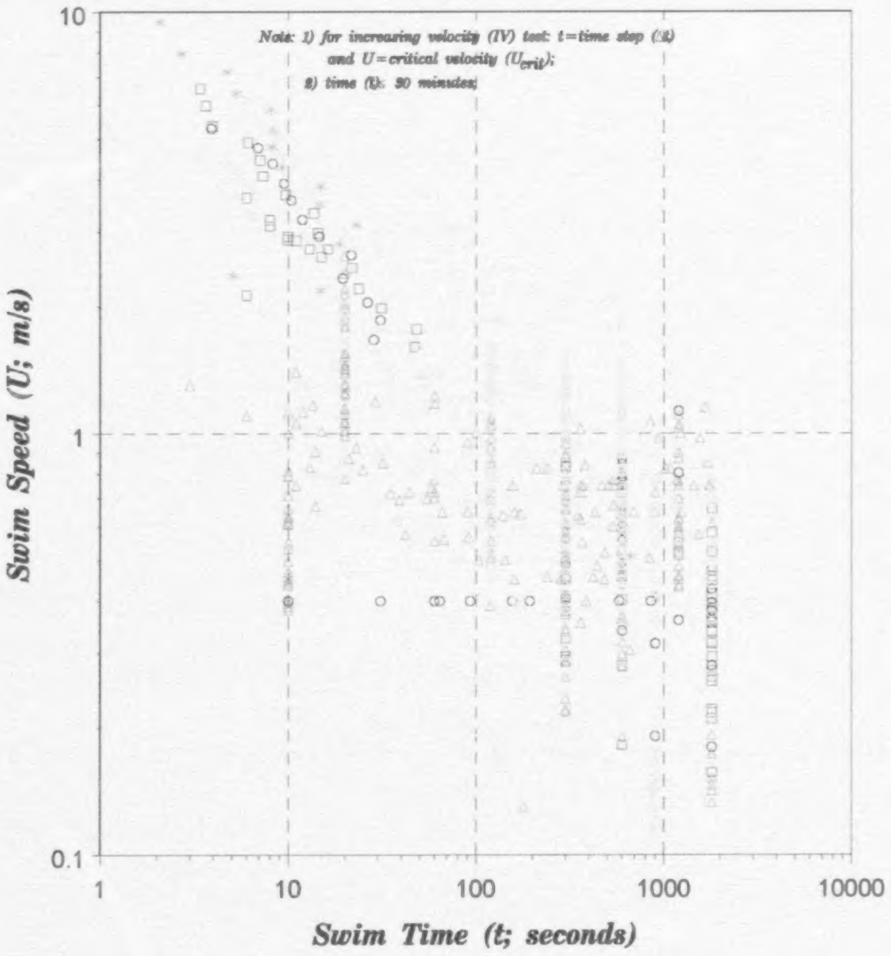


Figure F5-a. Processed data for the Salmon and Walleye Group; time-to-fatigue verus swim speed (m/s). Blue squares are Catostomidae; red triangles are Cyprinidae; green stars are Moronidae; black circles are Percidae; turquoise diamonds are Salmonidae.

Table F5-a. Data summary. Fish count 17085, record count 1293.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.197	0.176	0.021	0.927	0.906	574
T (C)	14.1	4.8	3.1	32.9	29.8	181
U (m/s)	1.071	1.038	0.11	9.45	9.34	718
t_e (s)	327	473	2	1800	1798	372
$t_{\Delta t}$ (s)	539	479	10	1800	1790	11

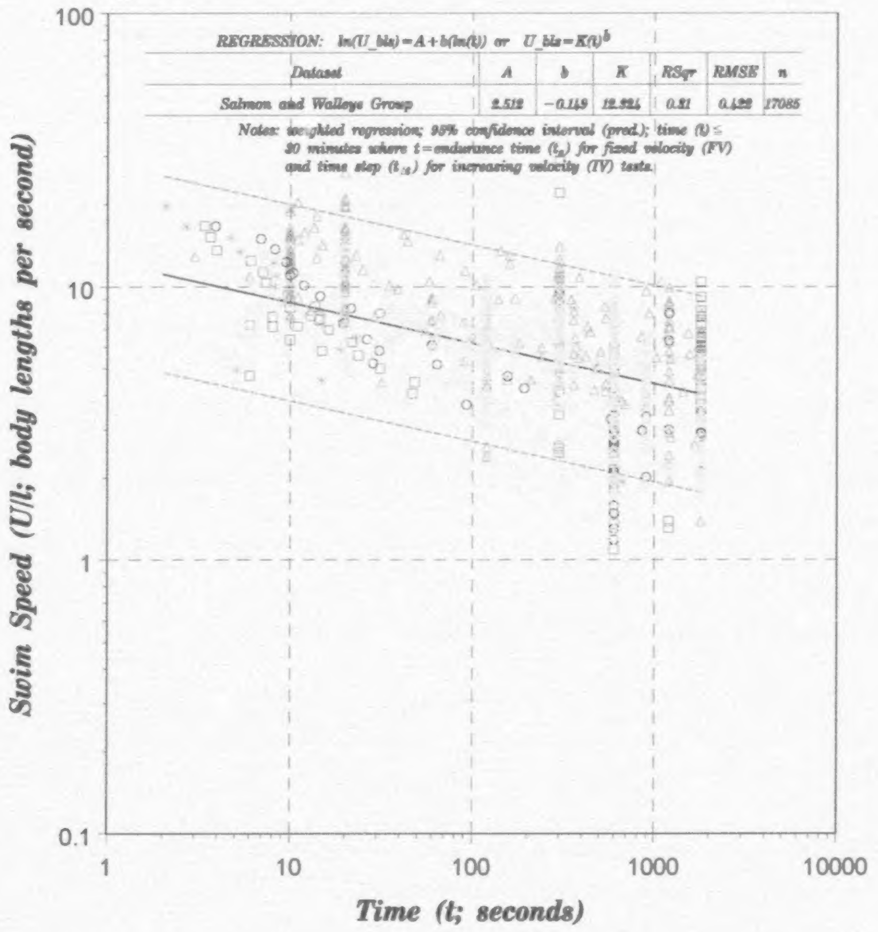


Figure F5-b Processed data for the Salmon and Walleye Group; time-to-fatigue verus swim speed (body lengths per second). Blue squares are Catostomidae; red triangles are Cyprinidae; green stars are Moronidae; black circles are Percidae; turquoise diamonds are Salmonidae.

Table F5-b. Data summary. Fish count 17085, record count 1293.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.197	0.196	0.021	0.927	0.906	574
T (C)	13.9	5.1	3.1	32.9	29.8	181
U (m/s)	1.206	1.296	0.11	9.45	9.34	718
t_e (s)	426	543	2	1800	1798	372
$t_{\Delta t}$ (s)	536	516	10	1800	1790	11

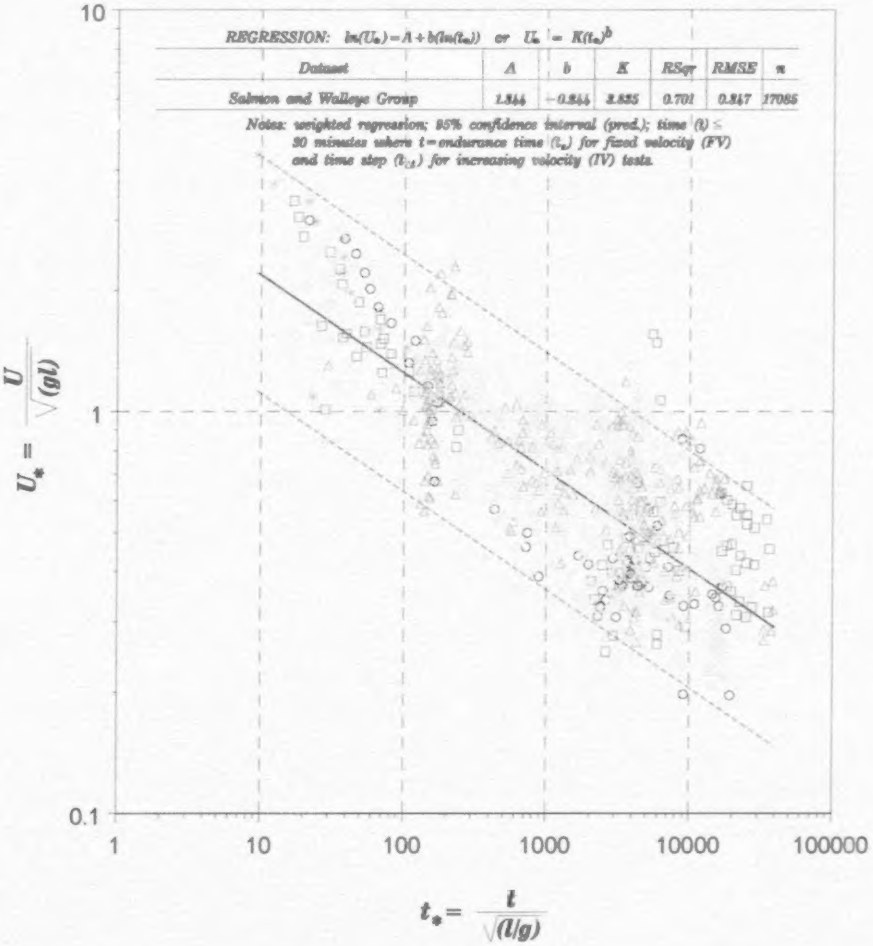
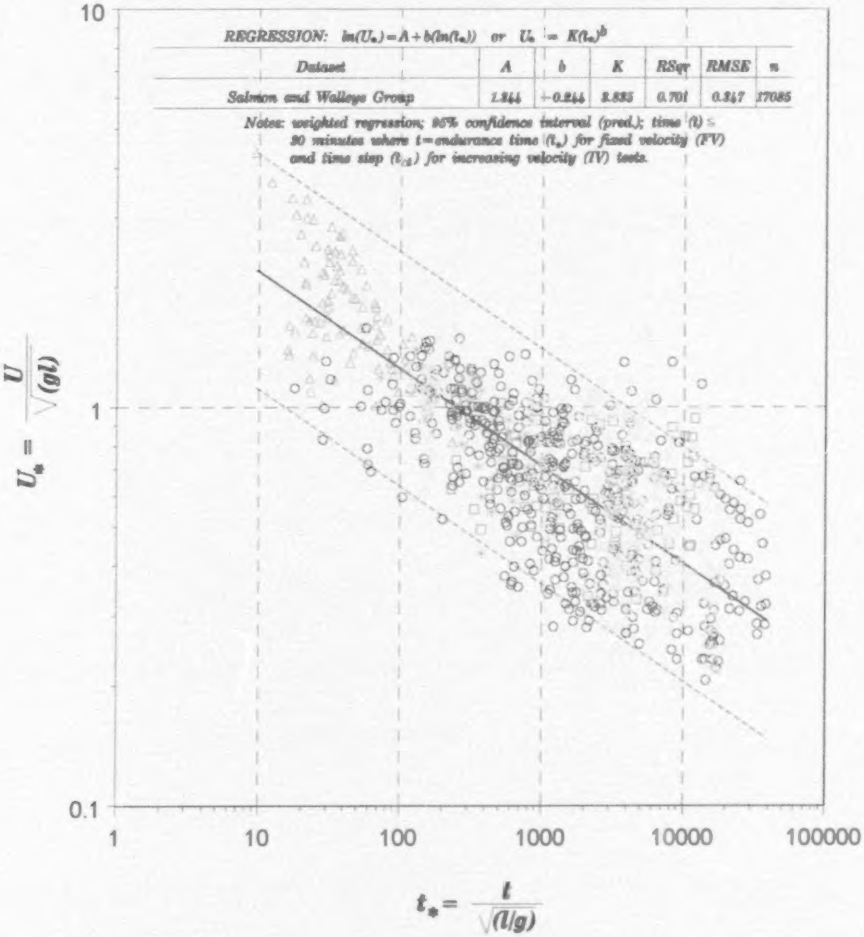


Figure F5-c. Processed data for the Salmon and Walleye Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Catostomidae; red triangles are Cyprinidae; green stars are Moronidae; black circles are Percidae; turquoise diamonds are Salmonidae.

Table F5-c. Data summary. Fish count 17085, record count 1293.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.197	0.196	0.021	0.927	0.906	574
T (C)	13.9	5.1	3.1	32.9	29.8	181
U (m/s)	1.206	1.296	0.11	9.45	9.34	718
t_e (s)	426	543	2	1800	1798	372
$t_{\Delta t}$ (s)	536	516	10	1800	1790	11



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Salmon and Walleye Group	1.344	−0.244	3.835	0.701	0.347	17085

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure F5-d. Processed data for the Salmon and Walleye Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are data from open channel (OC) flume tanks (constrained); red triangles are data from OC flume tanks; green stars are data from rotating chamber; black circles are swim tunnel with fixed velocity (FV); turquoise diamonds are data from swim tunnel with increasing velocity (IV).

Table F5-d. Data summary. Fish count 17085, record count 1293.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.197	0.196	0.021	0.927	0.906	574
T (C)	13.9	5.1	3.1	32.9	29.8	181
U (m/s)	1.206	1.296	0.11	9.45	9.34	718
t_e (s)	426	543	2	1800	1798	372
$t_{\Delta t}$ (s)	536	516	10	1800	1790	11

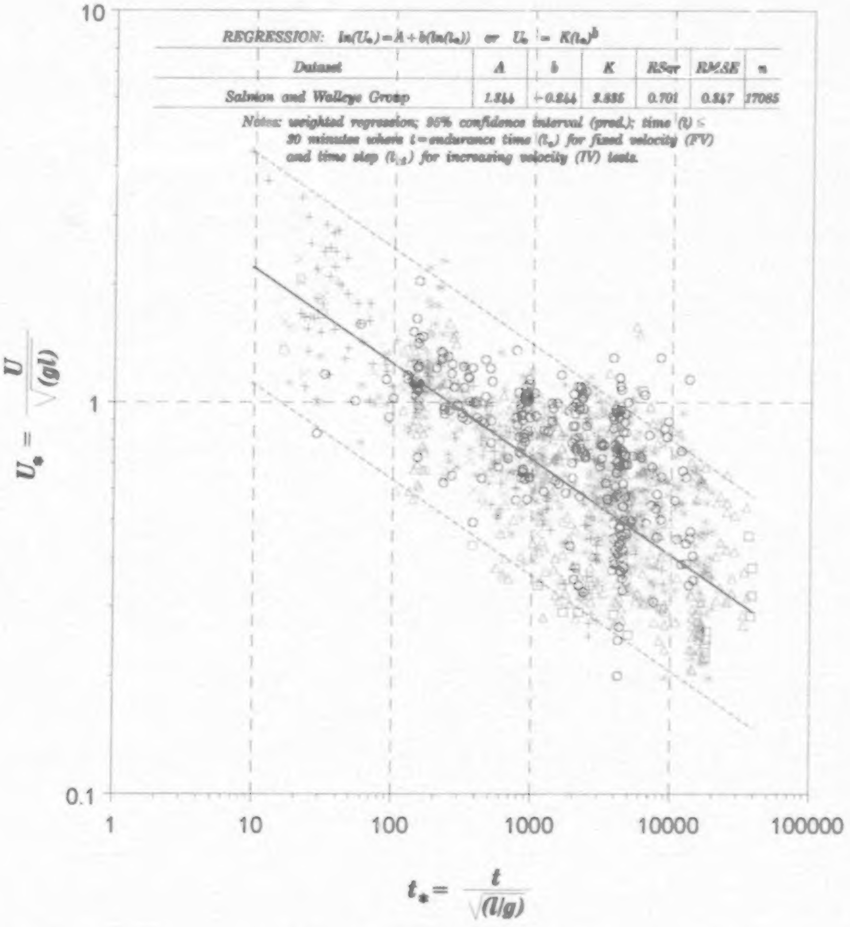


Figure F5-e. Processed data for the Salmon and Walleye Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are data from fishes less than 0.025 m length; red triangles are data from fishes of 0.025-0.075 m length; green stars are fishes of 0.075-0.15 m length; black circles are fishes of 0.15-0.25 m length; turquoise diamonds are fishes of 0.25-0.40 m length; blue crosses are fishes of 0.40-0.65 m length; red x's are fishes of 0.65-0.80 m length; green squares are fishes of 0.80-1.00 m length.

Table F5-e. Data summary. Fish count 17085, record count 1293.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.197	0.196	0.021	0.927	0.906	574
T (C)	13.9	5.1	3.1	32.9	29.8	181
U (m/s)	1.206	1.296	0.11	9.45	9.34	718
t_e (s)	426	543	2	1800	1798	372
$t_{\Delta t}$ (s)	536	516	10	1800	1790	11

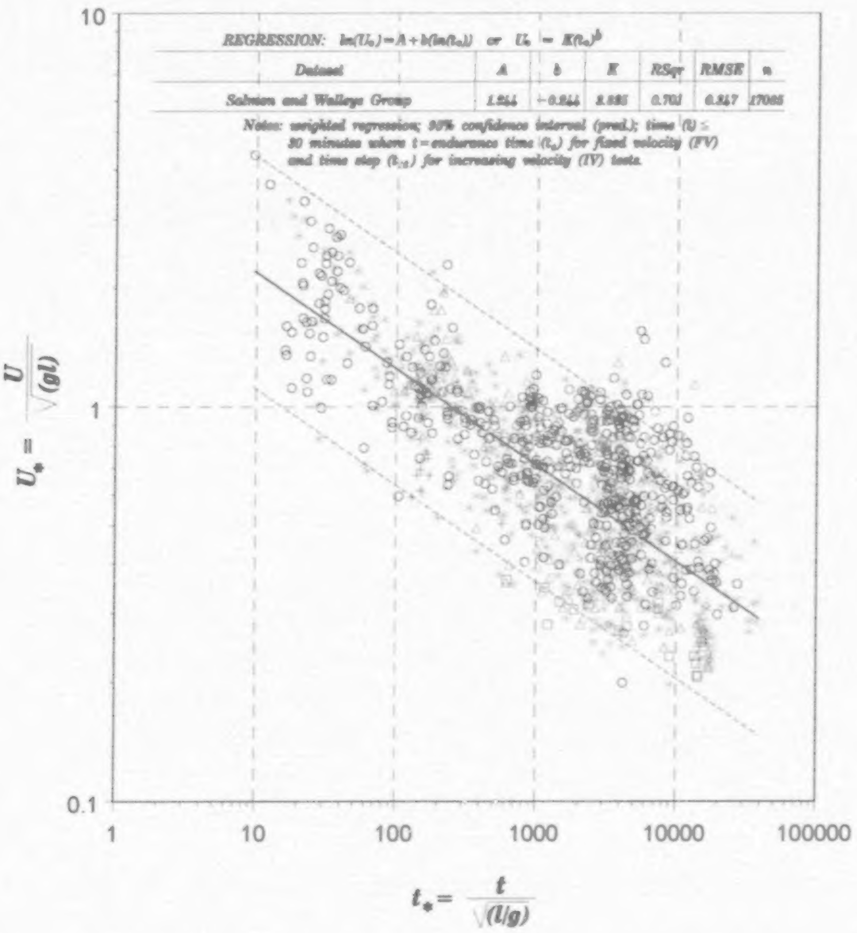


Figure F5-f. Processed data for the Salmon and Walleye Group by temperature groups; time-to-fatigue verus swim speed (m/s). Blue squares are data from 0-5°C; red triangles are data from 5-10°C; green stars are data from 10-15°C; black circles are data from 15-20°C; turquoise diamonds are data from 20-25°C; blue crosses are data from 25-30°C; red x's from 30-35°C.

Table F5-f. Data summary. Fish count 17085, record count 1293.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.197	0.196	0.021	0.927	0.906	574
T (C)	13.9	5.1	3.1	32.9	29.8	181
U (m/s)	1.206	1.296	0.11	9.45	9.34	718
t_e (s)	426	543	2	1800	1798	372
$t_{\Delta t}$ (s)	536	516	10	1800	1790	11

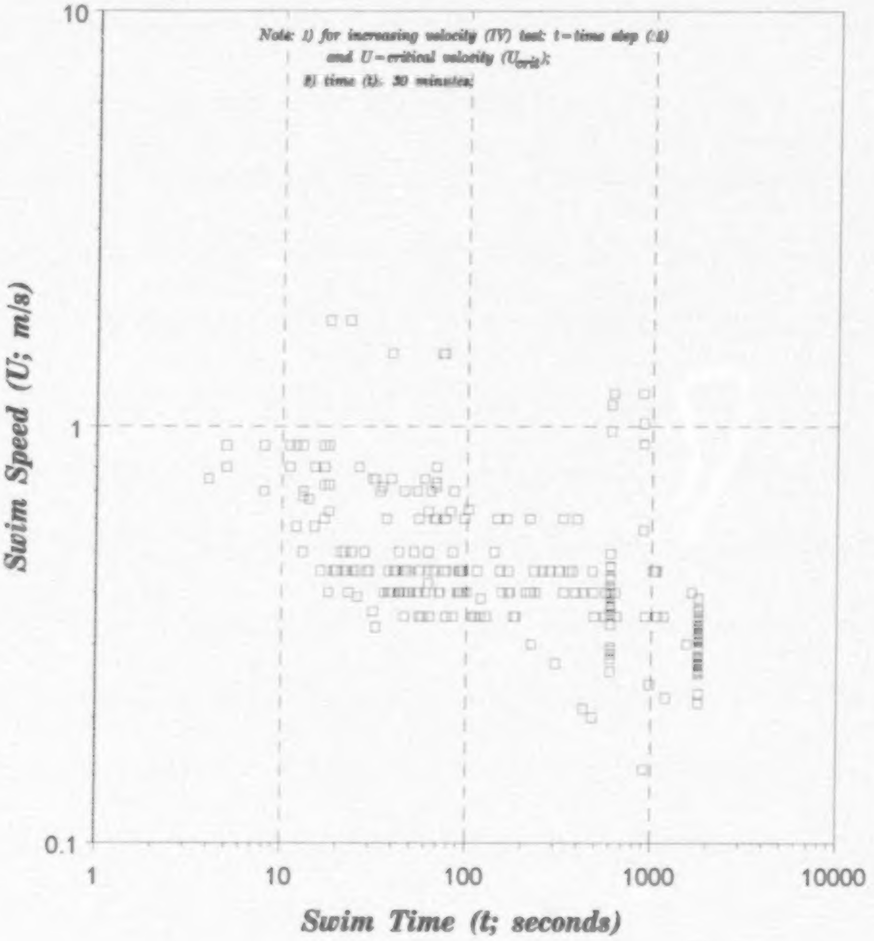


Figure F6-a. Processed data for the Sturgeon Group; time-to-fatigue verus swim speed (m/s). Blue squares are Acipenseridae.

Table F6-a. Data summary. Fish count 1008, record count 278.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.27	0.204	0.066	1.32	1.254	109
T (C)	14.3	5.7	5	25	20	11
U (m/s)	0.486	0.242	0.15	1.8	1.65	97
t_e (s)	189	320	4	1797	1793	147
$t_{\Delta t}$ (s)	1352	580	120	1800	1680	5

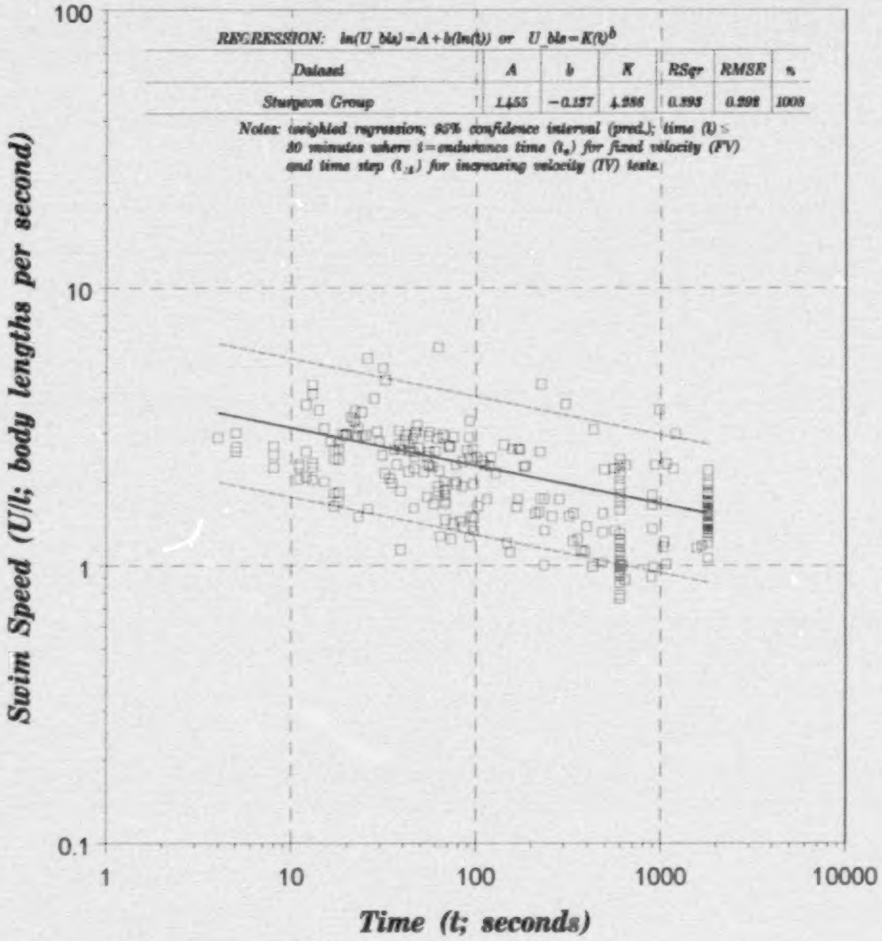


Figure F6-b Processed data for the Sturgeon Group; time-to-fatigue verus swim speed (body lengths per second). Blue squares are Acipenseridae.

Table F6-b. Data summary. Fish count 1008, record count 278.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.225	0.16	0.066	1.32	1.254	109
T (C)	14.7	5.8	5	25	20	11
U (m/s)	0.435	0.196	0.15	1.8	1.65	97
t_e (s)	186	323	4	1797	1793	147
$t_{\Delta t}$ (s)	1459	544	120	1800	1680	5

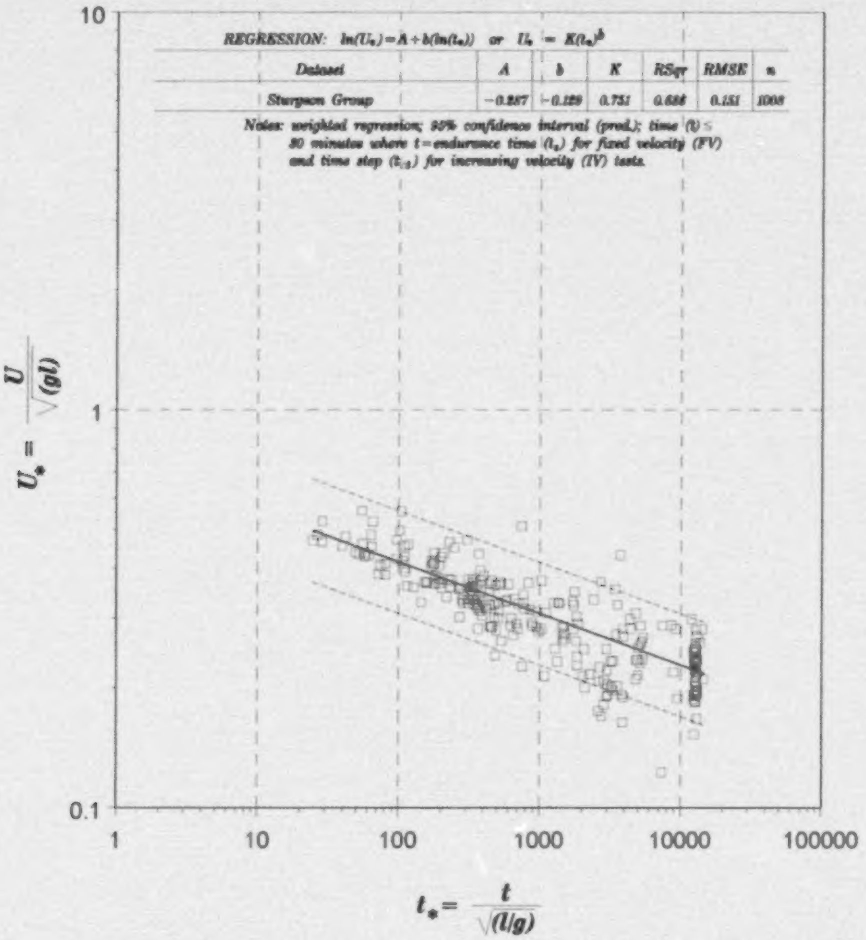


Figure F6-c. Processed data for the Sturgeon Group; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Acipenseridae.

Table F6-c. Data summary. Fish count 1008, record count 278.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.225	0.16	0.066	1.32	1.254	109
T (C)	14.7	5.8	5	25	20	11
U (m/s)	0.435	0.196	0.15	1.8	1.65	97
t_e (s)	186	323	4	1797	1793	147
$t_{\Delta t}$ (s)	1459	544	120	1800	1680	5

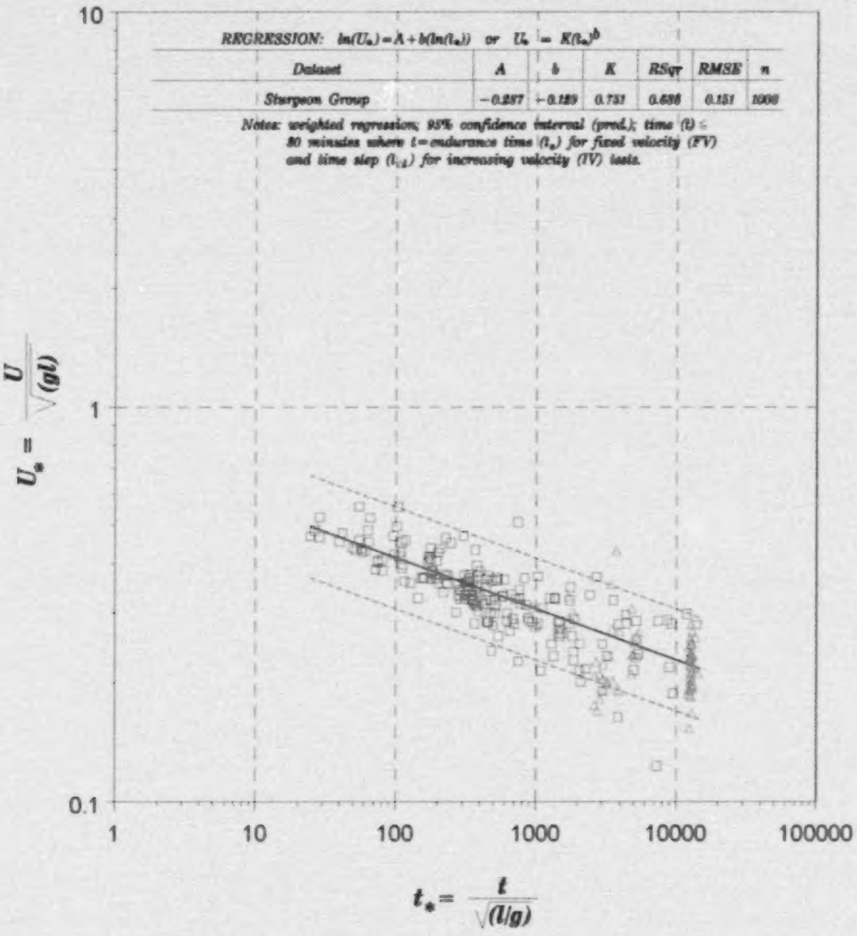


Figure F6-d. Processed data for the Sturgeon Group by test apparatus; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are data from swim tunnels with fixed velocity (FV); red triangles are data from swim tunnels with increasing velocity (IV).

Table F6-d. Data summary. Fish count 1008, record count 278.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.225	0.16	0.066	1.32	1.254	109
T (C)	14.7	5.8	5	25	20	11
U (m/s)	0.435	0.196	0.15	1.8	1.65	97
t_e (s)	186	323	4	1797	1793	147
$t_{\Delta t}$ (s)	1459	544	120	1800	1680	5

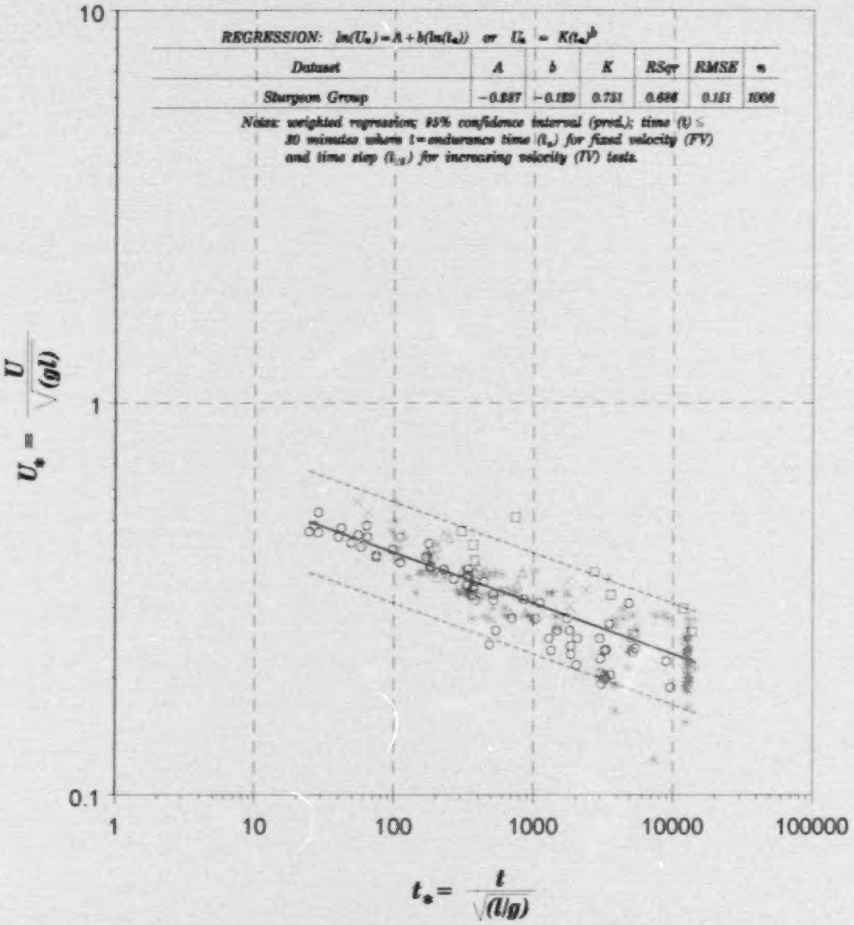


Figure F6-e. Processed data for the Sturgeon Group by length groups; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are fishes of 0.025-0.075 m length; red triangles are fishes of 0.075-0.15 m length; green stars are fishes of 0.15-0.25 m length; black circles are fishes of 0.25-0.40 m length; turquoise diamonds are fishes of 0.40-0.65 m length; blue crosses are fishes of 0.65-0.80 m length; red x's are fishes of 1.00-1.50 m length.

Table F6-e. Data summary. Fish count 1008, record count 278.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.225	0.16	0.066	1.32	1.254	109
T (C)	14.7	5.8	5	25	20	11
U (m/s)	0.435	0.196	0.15	1.8	1.65	97
t_e (s)	186	323	4	1797	1793	147
$t_{\Delta t}$ (s)	1459	544	120	1800	1680	5

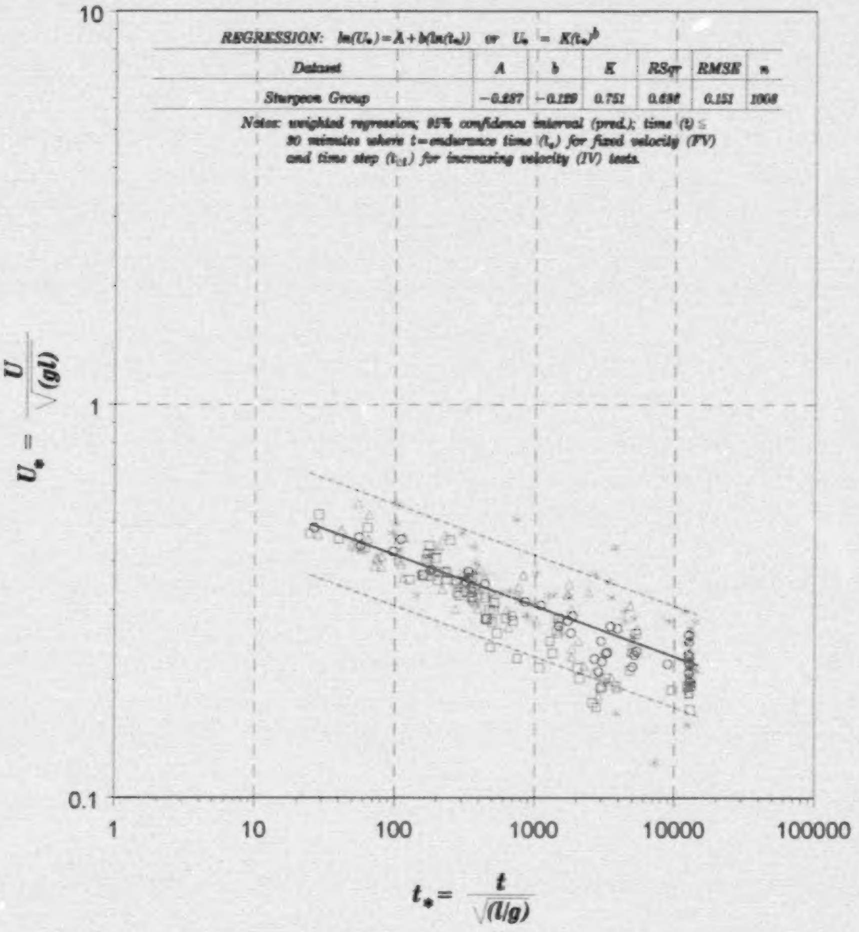


Figure F6-f. Processed data for the Sturgeon Group; time-to-fatigue verus swim speed(m/s). Blue squares are data from 5-10°C; red triangles are data from 10-15°C; green stars are data from 15-20°C; black circles are data from 20-25°C; turquoise diamonds are data from 25-30°C.

Table F6-f. Data summary. Fish count 1008, record count 278.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.225	0.16	0.066	1.32	1.254	109
T (C)	14.7	5.8	5	25	20	11
U (m/s)	0.435	0.196	0.15	1.8	1.65	97
t_e (s)	186	323	4	1797	1793	147
$t_{\Delta t}$ (s)	1459	544	120	1800	1680	5

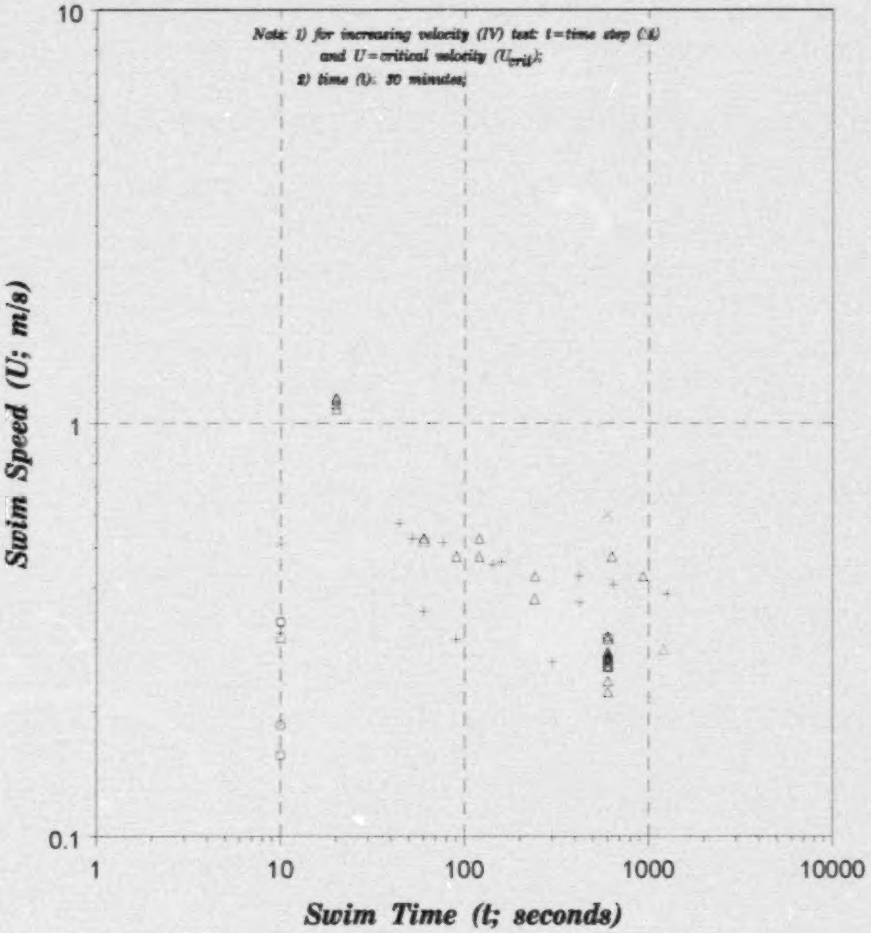


Figure F7-a. Processed data for the Unclassified Species; time-to-fatigue verus swim speed (m/s). Blue squares are Atherinidae; red triangles are Balitoridae; green stars are Characidae; black circles are Cichlidae; turquoise diamonds are Cyprinodontidae; blue crosses are Gasterosteidae; red x's are Hiodontidae; green squares are Lepisosteidae; black traingles are Osmeridae; turquoise stars are Plecoglossidae, blue circles are Poeciliidae.

Table F7-a. Data summary. Fish count 654, record count 52.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.072	0.046	0.023	0.266	0.243	40
T (C)	16.7	5.3	6	31.7	25.7	24
U (m/s)	0.465	0.298	0.157	1.5	1.343	43
t_e (s)	274	318	25	1261	1236	18
$t_{\Delta t}$ (s)	380	329	10	1200	1190	5

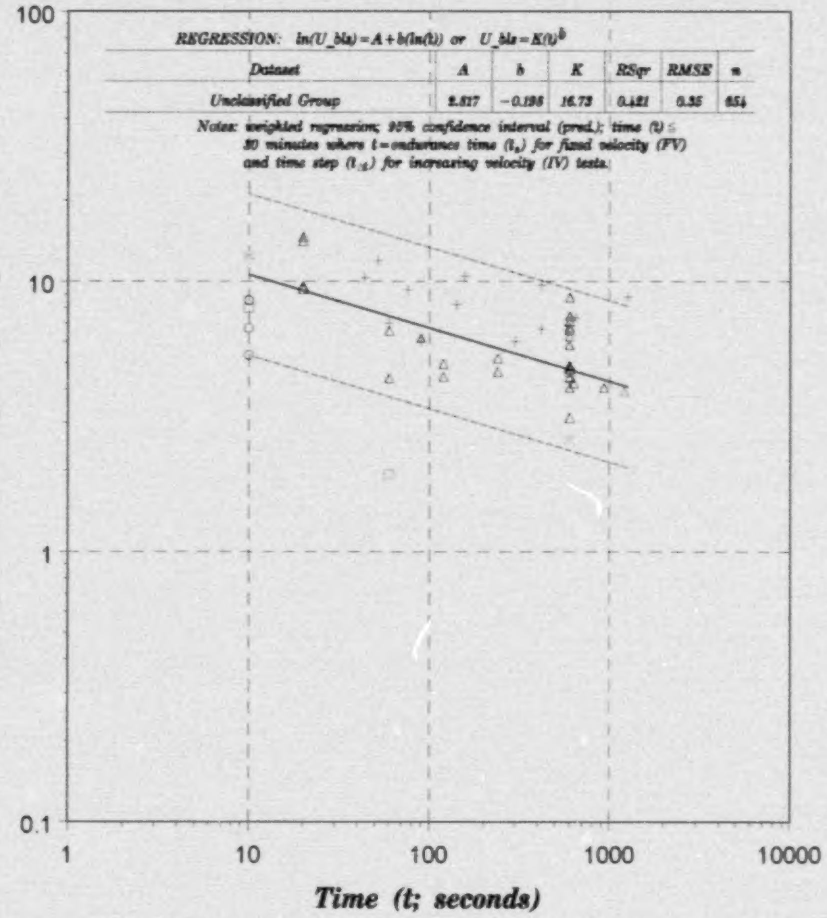
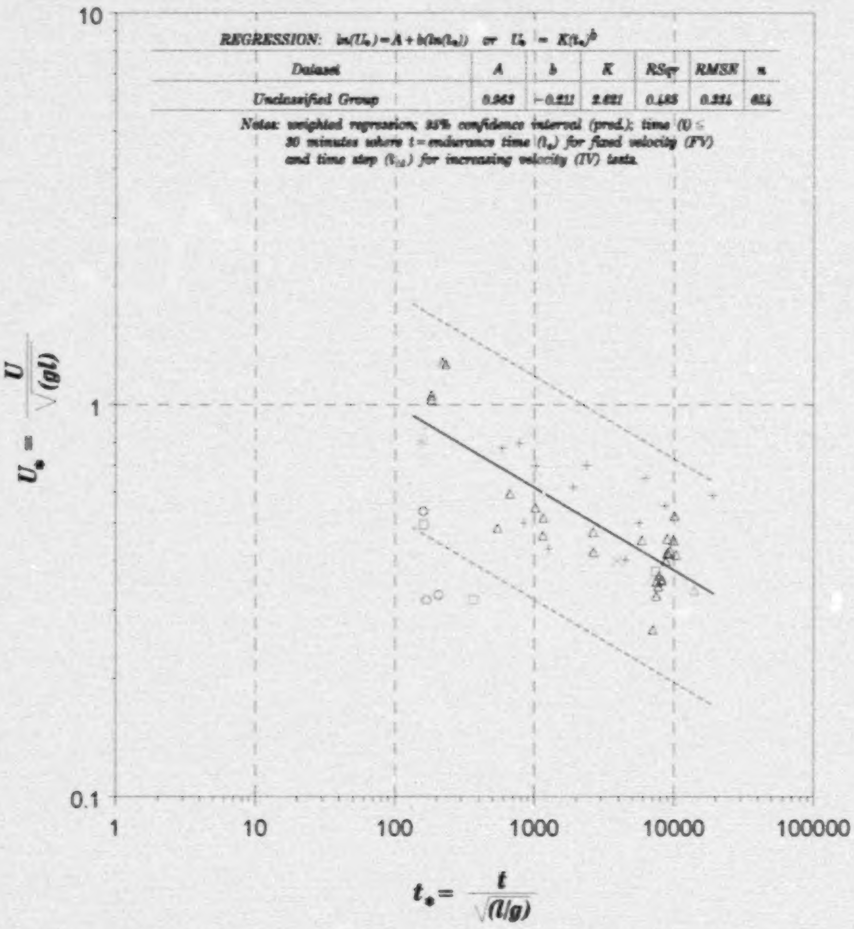


Figure F7-b Processed data for the Unclassified Species; time-to-fatigue verus swim speed (body lengths per second). Blue squares are Atherinidae; red triangles are Balitoridae; green stars are Characidae; black circles are Cichlidae; turquoise diamonds are Cyprinodontidae; blue crosses are Gasterosteidae; red x's are Hiodontidae; green squares are Lepisosteidae; black traingles are Osmeridae; turquoise stars are Plecoglossidae, blue circles are Poeciliidae.

Table F7-b. Data summary. Fish count 654, record count 52.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.085	0.038	0.023	0.266	0.243	40
T (C)	14.8	5.3	6	31.7	25.7	24
U (m/s)	0.634	0.36	0.157	1.5	1.343	43
t_e (s)	267	297	25	1261	1236	18
$t_{\Delta t}$ (s)	196	296	10	1200	1190	5



REGRESSION: $\ln(U_*) = A + b(\ln(t_*))$ or $U_* = K(t_*)^b$

Dataset	A	b	K	RSqr	RMSE	n
Unclassified Group	0.963	-0.211	2.621	0.485	0.224	654

Notes: weighted regression; 95% confidence interval (pred.); time (t) ≤ 30 minutes where t = endurance time (t_e) for fixed velocity (FV) and time step ($t_{\Delta t}$) for increasing velocity (IV) tests.

Figure F7-c. Processed data for the Unclassified Species; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are Atherinidae; red triangles are Balitoridae; green stars are Characidae; black circles are Cichlidae; turquoise diamonds are Cyprinodontidae; blue crosses are Gasterosteidae; red x's are Hiodontidae; green squares are Lepisosteidae; black traingles are Osmeridae; turquoise stars are Plecoglossidae, blue circles are Poeciliidae.

Table F7-c. Data summary. Fish count 654, record count 52.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.085	0.038	0.023	0.266	0.243	40
T (C)	14.8	5.3	6	31.7	25.7	24
U (m/s)	0.634	0.36	0.157	1.5	1.343	43
t_e (s)	267	297	25	1261	1236	18
$t_{\Delta t}$ (s)	196	296	10	1200	1190	5

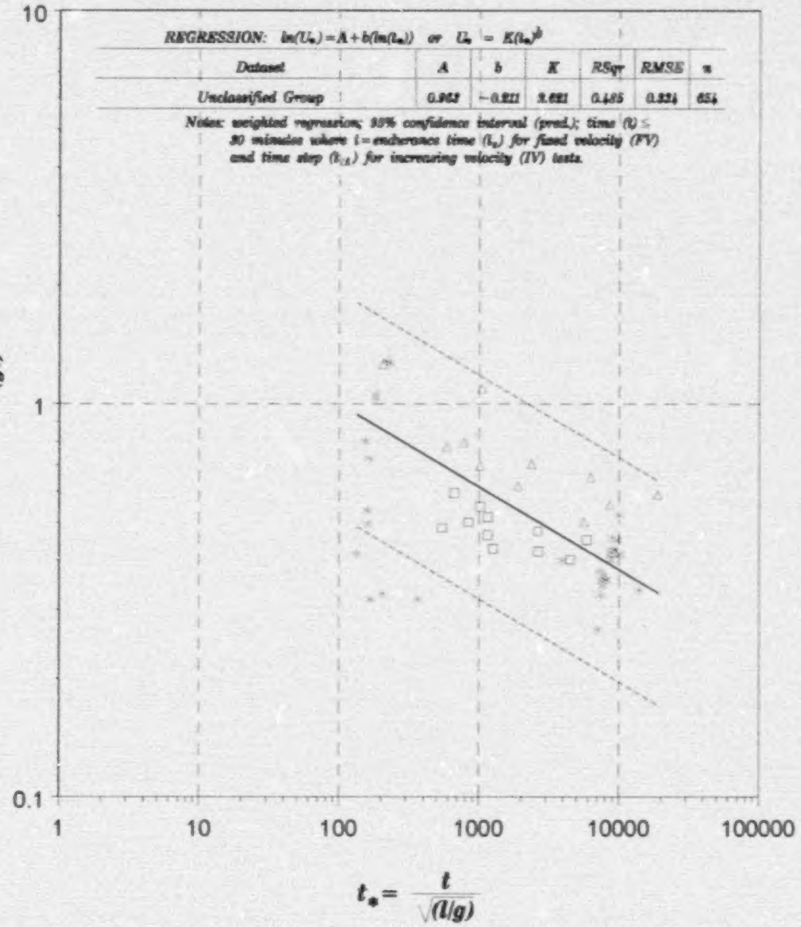


Figure F7-d. Processed data for the Unclassified Species; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are data from open channel flume tanks (constrained), red triangles are data from swim tunnels with fixed velocity (FV); green stars are data from swim tunnels with increasing velocity (IV).

Table F7-d. Data summary. Fish count 654, record count 52.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.085	0.038	0.023	0.266	0.243	40
T (C)	14.8	5.3	6	31.7	25.7	24
U (m/s)	0.634	0.36	0.157	1.5	1.343	43
t_e (s)	267	297	25	1261	1236	18
$t_{\Delta t}$ (s)	196	296	10	1200	1190	5

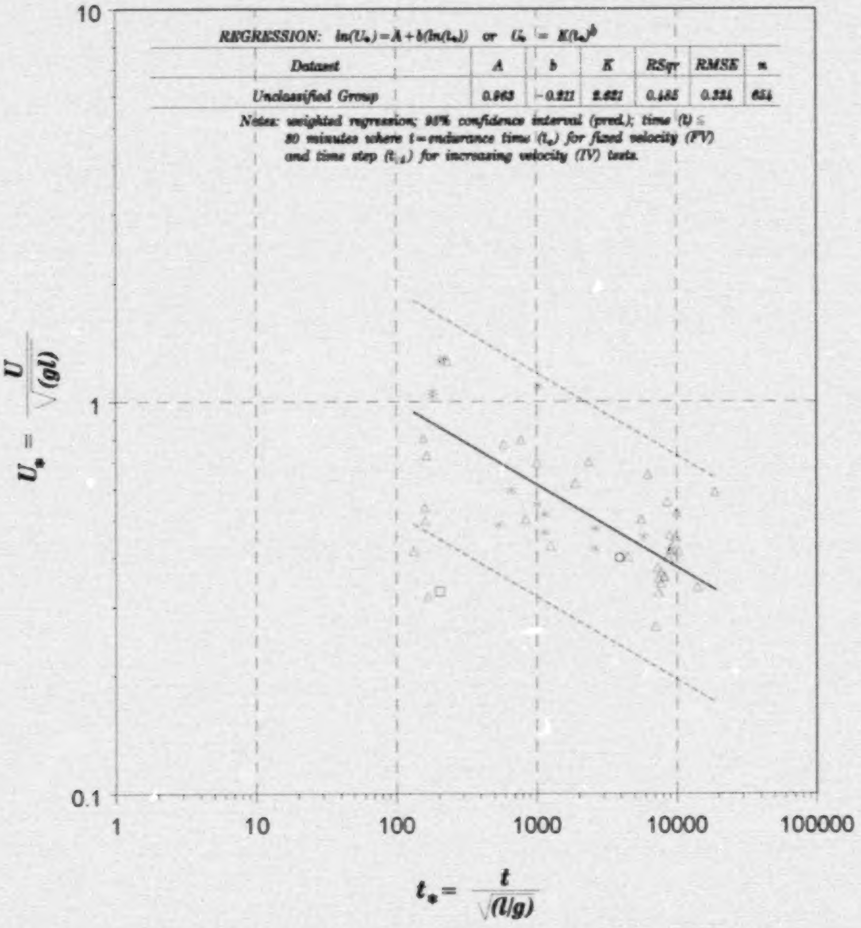


Figure F7-e. Processed data for the Unclassified Species; dimensionless time-to-fatigue versus dimensionless swim speed. Blue squares are fishes less than 0.025 m length; red triangles are fishes of 0.025-0.075 m length; green stars are fishes of 0.075-0.15 m length; black circles are fishes of 0.15-0.25 m length; turquoise diamonds are fishes of 0.25-0.40 m length.

Table F7-e. Data summary. Fish count 654, record count 52.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.085	0.038	0.023	0.266	0.243	40
T (C)	14.8	5.3	6	31.7	25.7	24
U (m/s)	0.634	0.36	0.157	1.5	1.343	43
t_e (s)	267	297	25	1261	1236	18
$t_{\Delta t}$ (s)	196	296	10	1200	1190	5

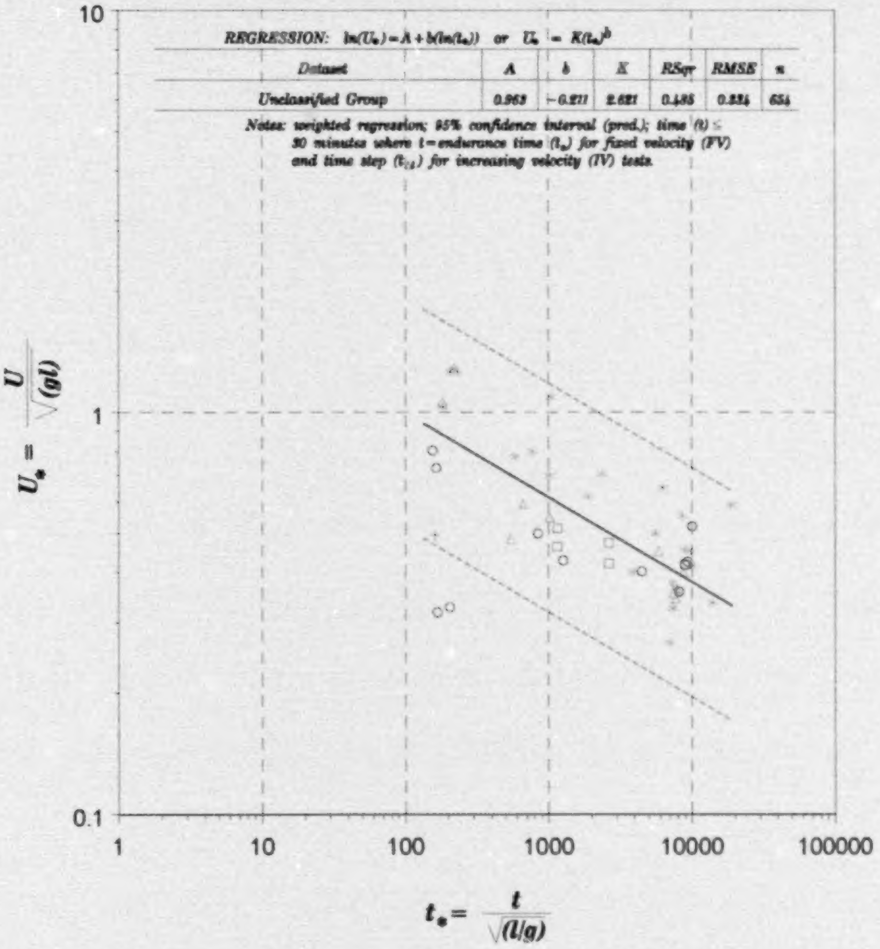


Figure F7-f. Processed data for the Unclassified Species; time-to-fatigue verus swim speed(m/s). Blue squares are data from 5-10°C; red triangles are data from 10-15 °C; green stars are data from 15-20°C; black circles are data from 20-25°C; turquoise diamonds are data from 25-30°C; blue crosses are data from 30-35°C.

Table F7-f. Data summary. Fish count 654, record count 52.

Variables	Mean	SD	Min	Max	Range	N
l (m)	0.085	0.038	0.023	0.266	0.243	40
T (C)	14.8	5.3	6	31.7	25.7	24
U (m/s)	0.634	0.36	0.157	1.5	1.343	43
t_e (s)	267	297	25	1261	1236	18
$t_{\Delta t}$ (s)	196	296	10	1200	1190	5

APPENDIX 1–SERIES G

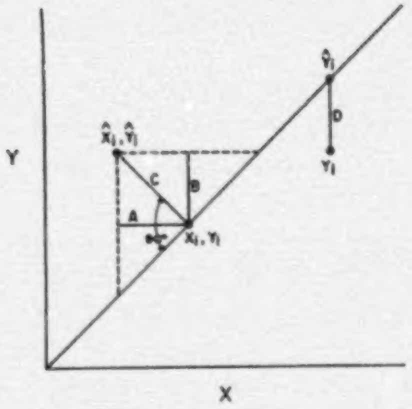
Processed Endurance Data

Dimensionless Swim Speed (U·) vs Dimensionless Time-to-Fatigue (t·)

Plotted by Group with Deming Regressions (6 graphs)

- In this series of graphs, the dimensionless endurance data for the grouped datasets are presented with regression lines that were derived using the Deming method rather than the traditional least squares regression analysis used in the previous graphs.
- Deming regressions were used to reduce the potential bias related to the lack of consistency in the independent and dependant variables for the different test methods in the data collection (i.e., for the fixed velocity test, swim time is the dependent variable and for the increasing velocity test, critical swimming speed is the dependent variable).
- Deming regressions produce predicted values that are independent of which variable is defined as dependent and independent.

Least-squares vs. Deming



Least-squares:
regression line minimizes B or residual errors in Y only

Deming method:
regression line minimizes both A and B or residual errors in X and Y, or C since $C^2=A^2+B^2$

Cornbleet and Gochman 1979

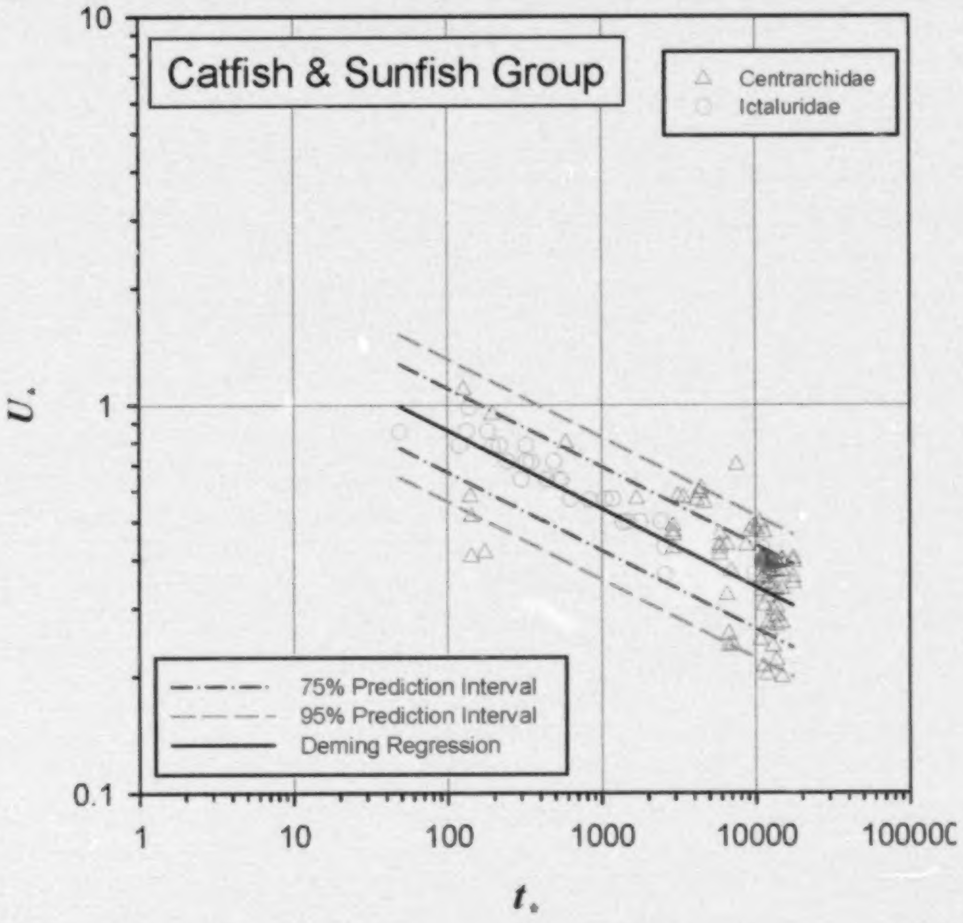


Figure G-1. Catfish and Sunfish Group using dimensionless variables with Deming Regression line and the 75% and 95% prediction intervals. Dimensionless Swim Speed (U) versus Swim Time (t*).*

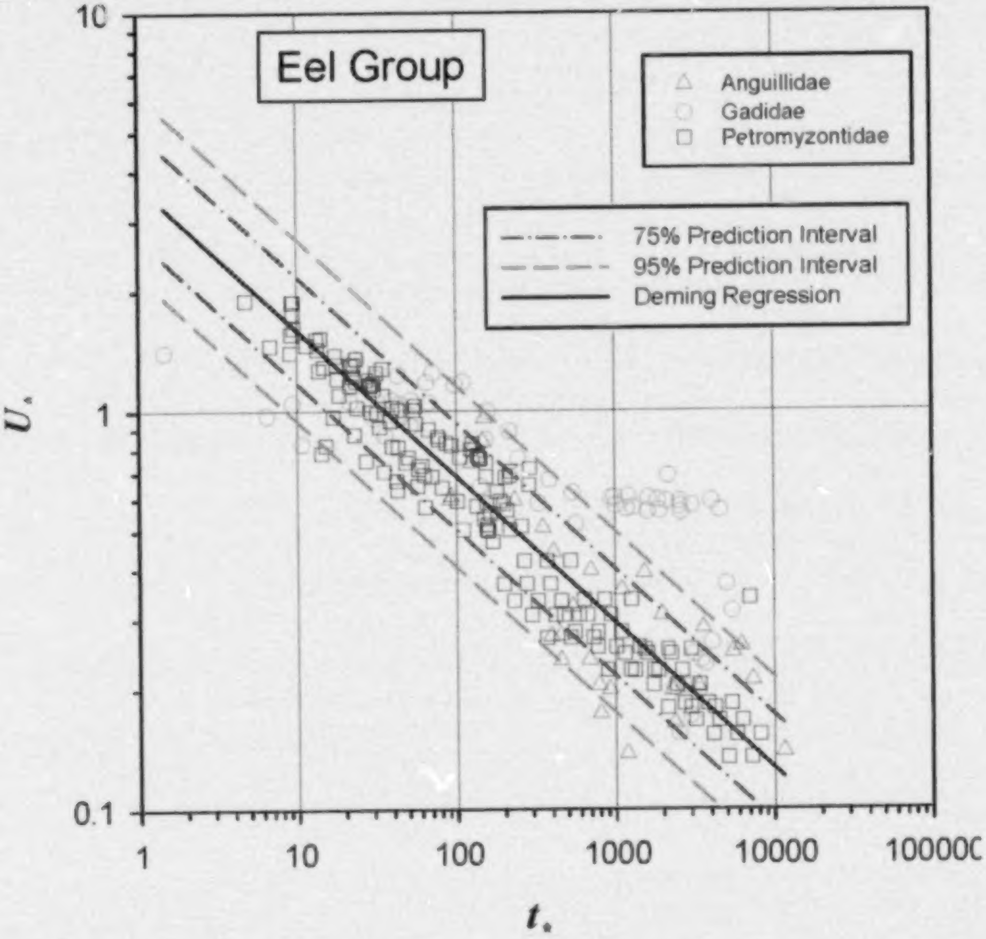


Figure G-2 Eel Group using dimensionless variables with Deming Regression line and the 75% and 95% prediction intervals. Dimensionless Swim Speed (U) versus Swim Time (t*).*

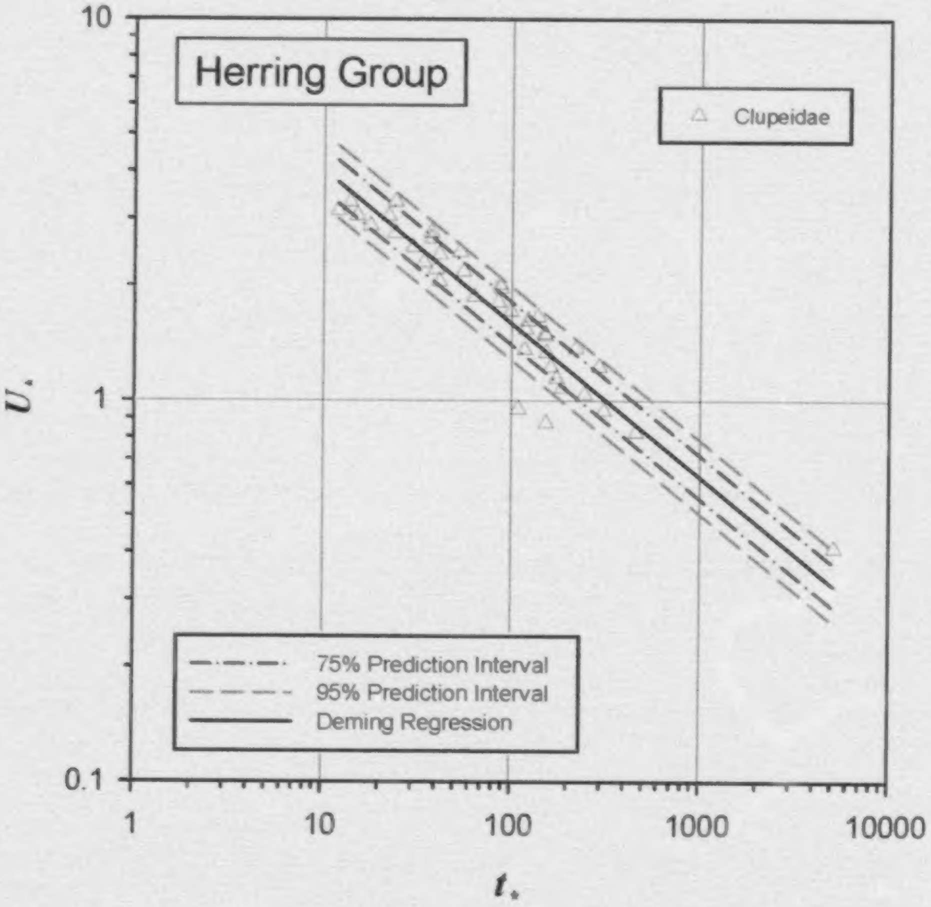


Figure G-3. Herring (Clupeidae) Group using dimensionless variables with Deming Regression line and the 75% and 95% prediction intervals. Dimensionless Swim Speed (U) versus Swim Time (t*).*

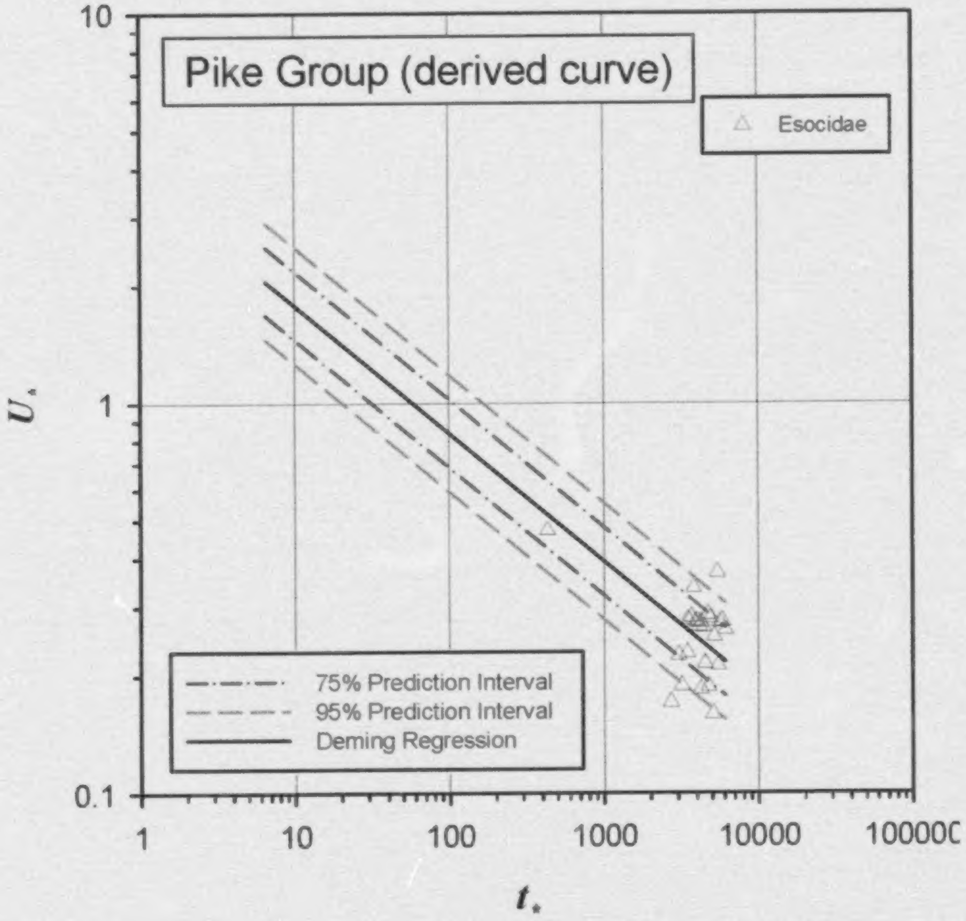


Figure G-4. Pike Group (derived curve) using dimensionless variables with Deming Regression line and the 75% and 95% prediction intervals. Dimensionless Swim Speed (U) versus Swim Time (t*).*

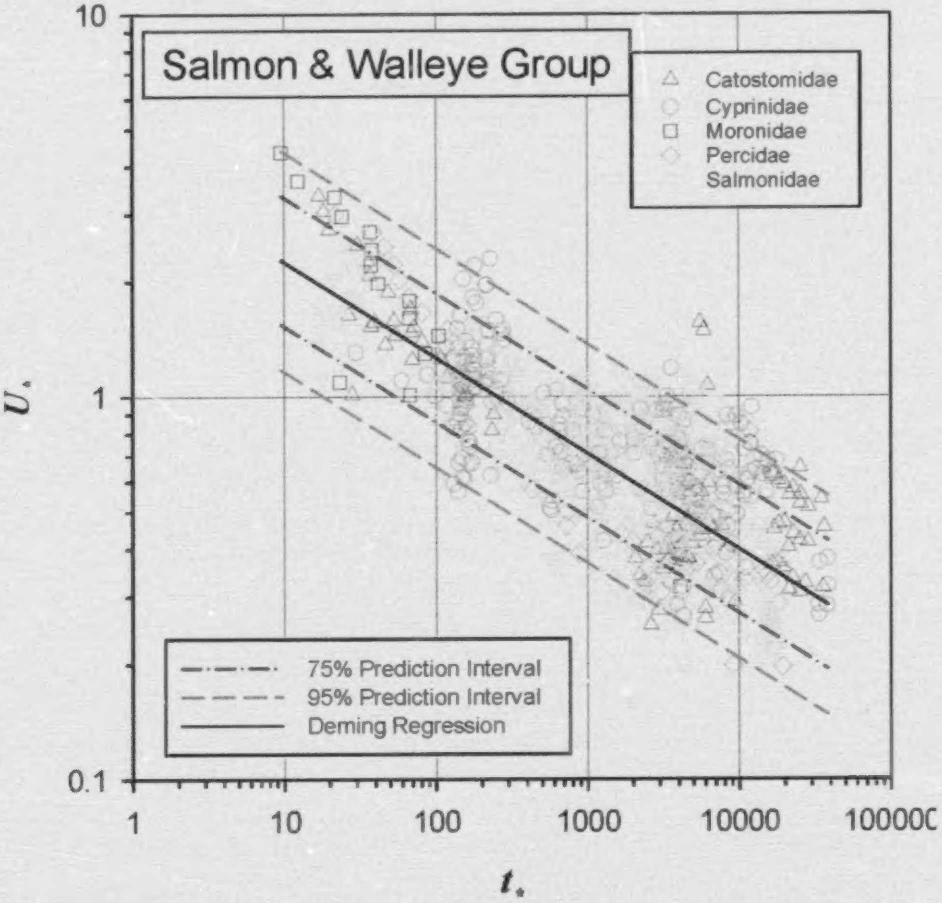


Figure G-5. Salmon and Walleye Group using dimensionless variables with Deming Regression line and the 75% and 95% prediction intervals. Dimensionless Swim Speed (U) versus Swim Time (t*).*

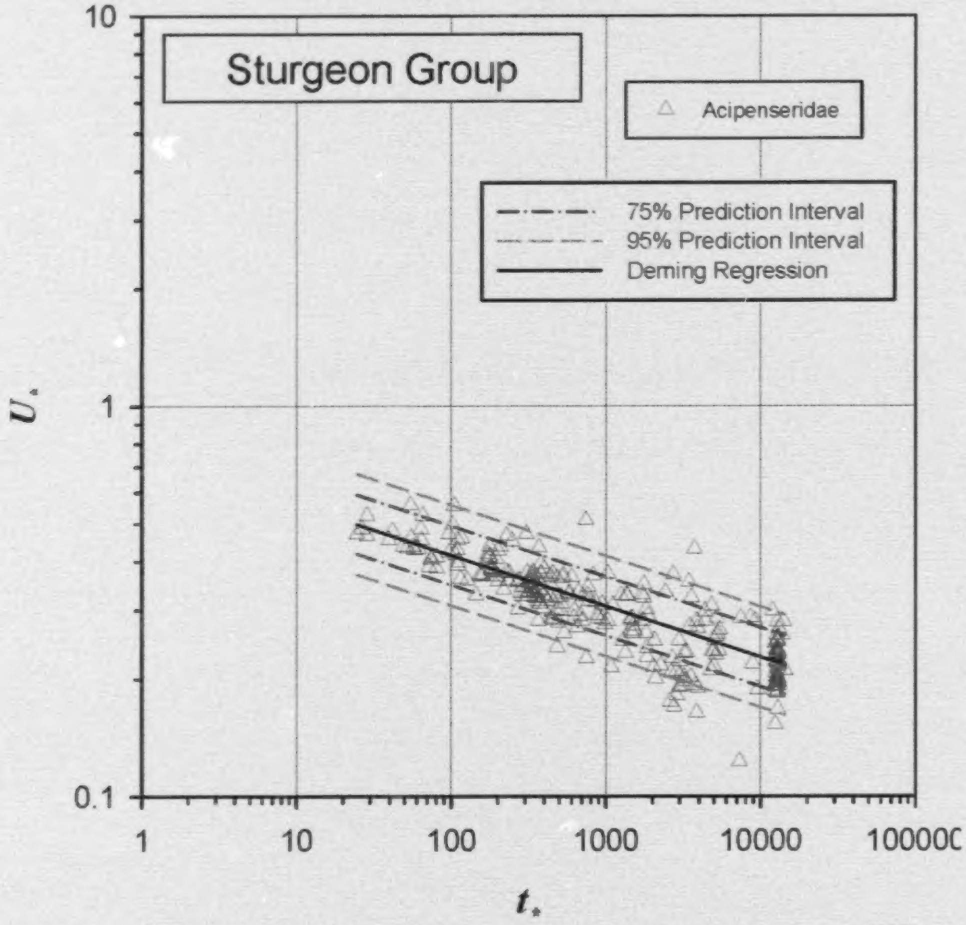


Figure G-6. Sturgeon Group using dimensionless variables with Deming Regression line and the 75% and 95% prediction intervals. Dimensionless Swim Speed (U) versus Swim Time (t*).*

APPENDIX 1–SERIES H

Calculated Endurance

Swim Speed (U; m/s) vs Time-to-Fatigue (t; sec)

Plotted by Group and Fish Length (18 graphs)

- Graphs of swimming endurance estimates (time-to-fatigue as a function of swimming speed) that were calculated from the dimensionless endurance regression equations and prediction intervals for groups and selected fish lengths.
- These plots are based on the Deming equations found in Appendix 2 - Table A2c.

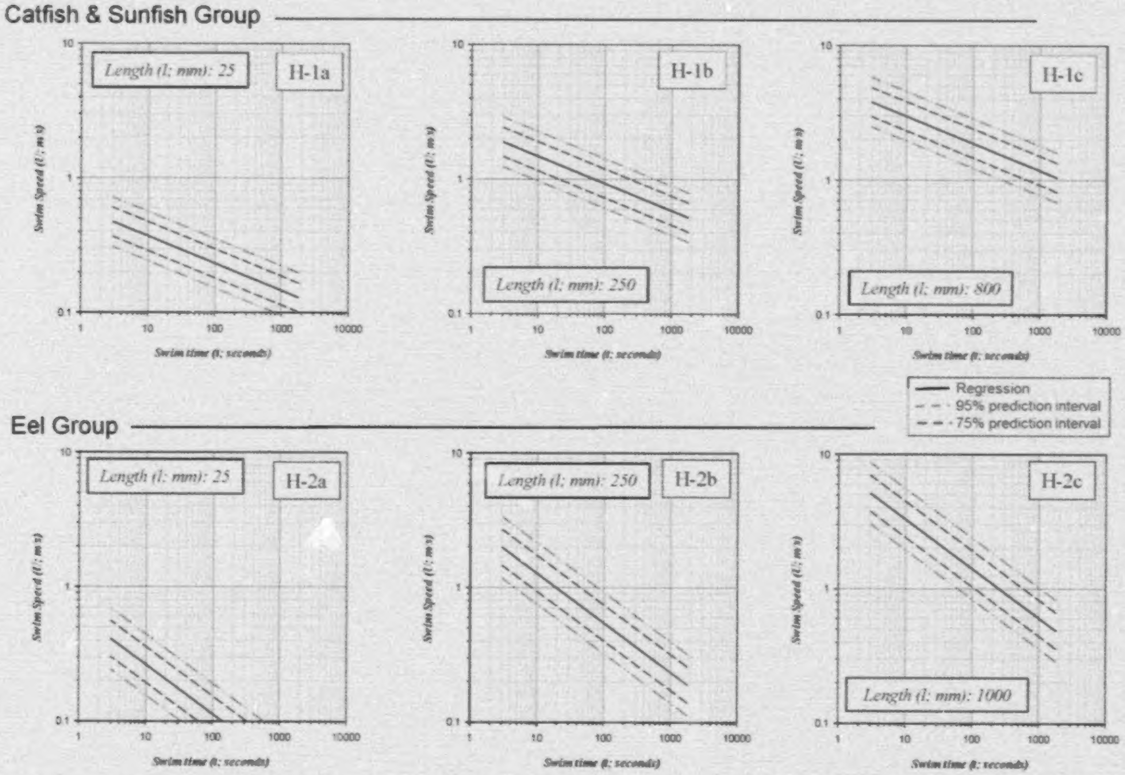


Figure H-2. Swim Speed (U; m/s) versus Time-to-fatigue (t; sec) calculated from dimensionless endurance curves for various fish lengths. Upper panel Catfish and sunfish group for 25, 250 and 800 mm lengths. Lower panel Eel group for 25, 250 and 1000 mm lengths.

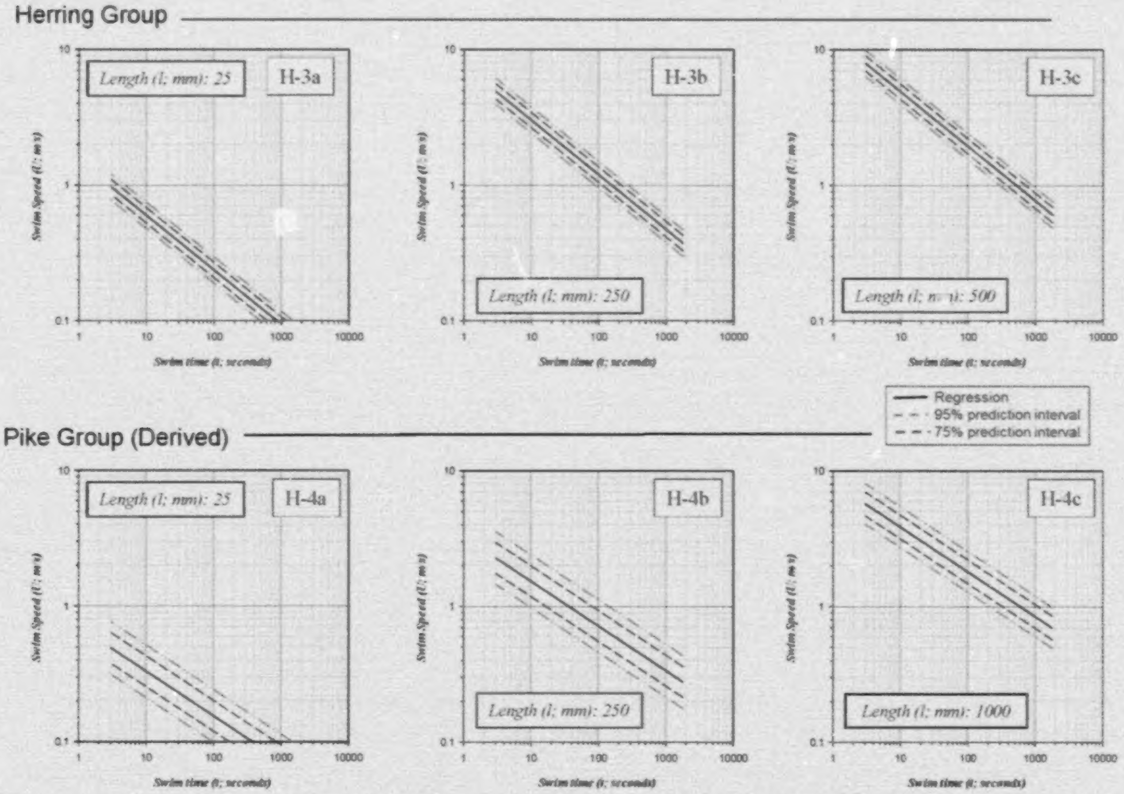


Figure H-3. Swim Speed (U; m/s) versus Time-to-fatigue (t; sec) calculated from dimensionless endurance curves for various fish lengths . Upper panel Herring group for 25, 250 and 500 mm lengths. Lower panel Pike group (derived) for 25, 250 and 1000 mm lengths.

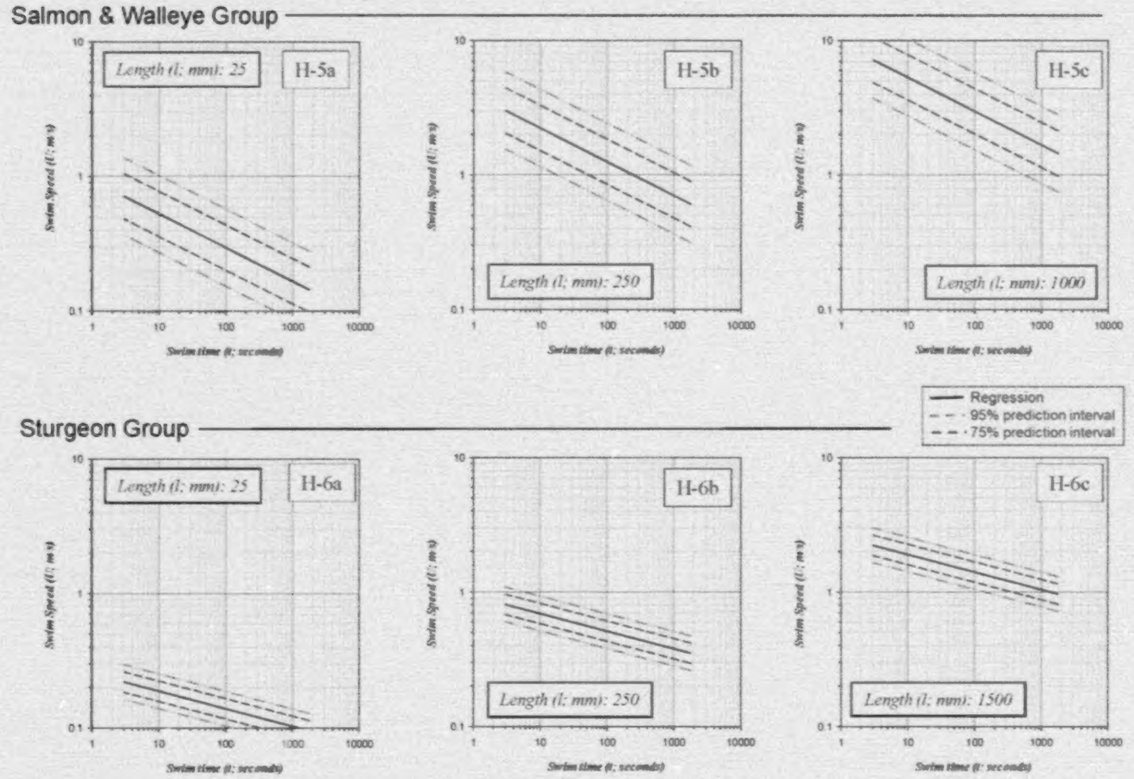


Figure H-3. Swim Speed (U; m/s) versus Time-to-fatigue (t; sec) calculated from dimensionless endurance curves for various fish lengths . Upper panel Salmon and Walleye groups for 25, 250 and 1000 mm lengths. Lower panel Sturgeon group for 25, 250 and 1500 mm lengths.

APPENDIX 1–SERIES I

Derived from Processed Endurance Data

Dimensionless Swim Distance (X_*) vs Dimensionless Water Velocity (V_*)

Plotted by Group (6 graphs)

- This series of graphs presents the dimensionless distance equations that were derived from the dimensionless endurance equations (see Section 4.3 of the report). The dimensionless distance equations (Table A2c) can be used to estimate swimming distance as a function of water velocity for the different groups and fish lengths.
- Distance was derived from the endurance data, since direct distance measurements are lacking data in the literature. For additional information see the report.

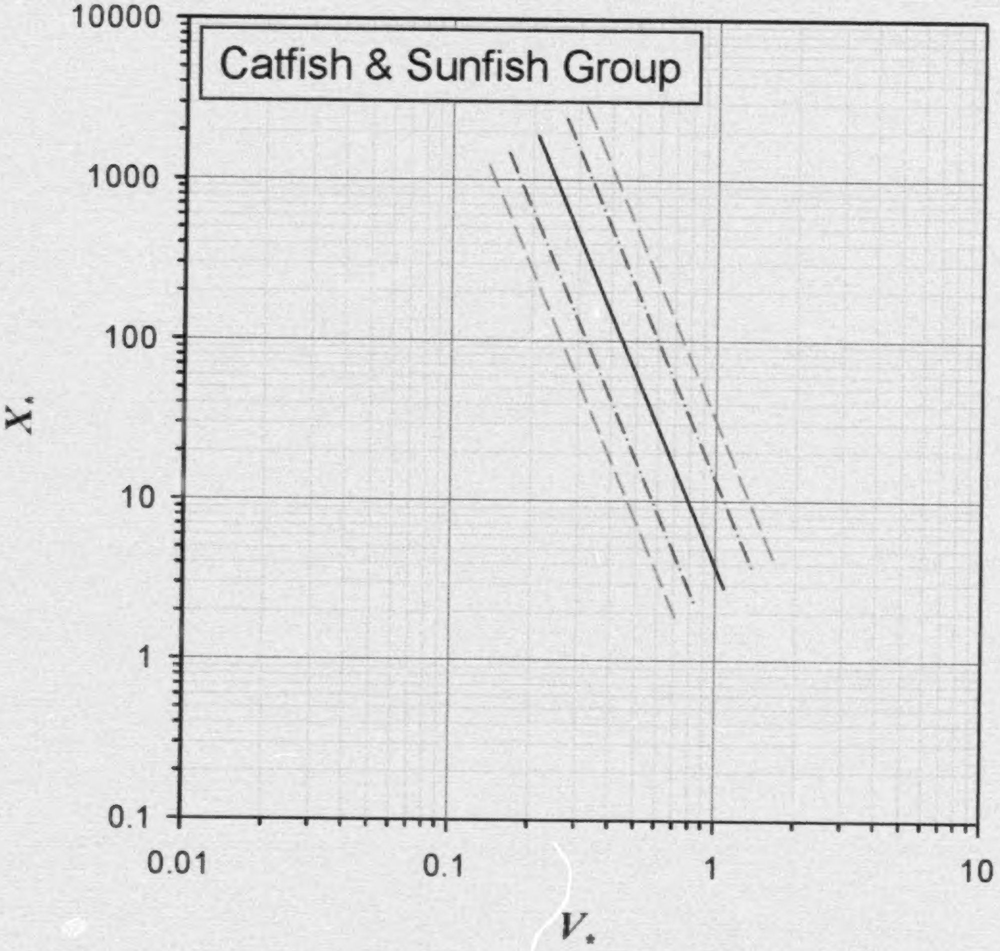


Figure I-1. Catfish and Sunfish Group dimensionless distance plots with 75% and 95% predictionintervals derived from dimensionless endurance relationships.

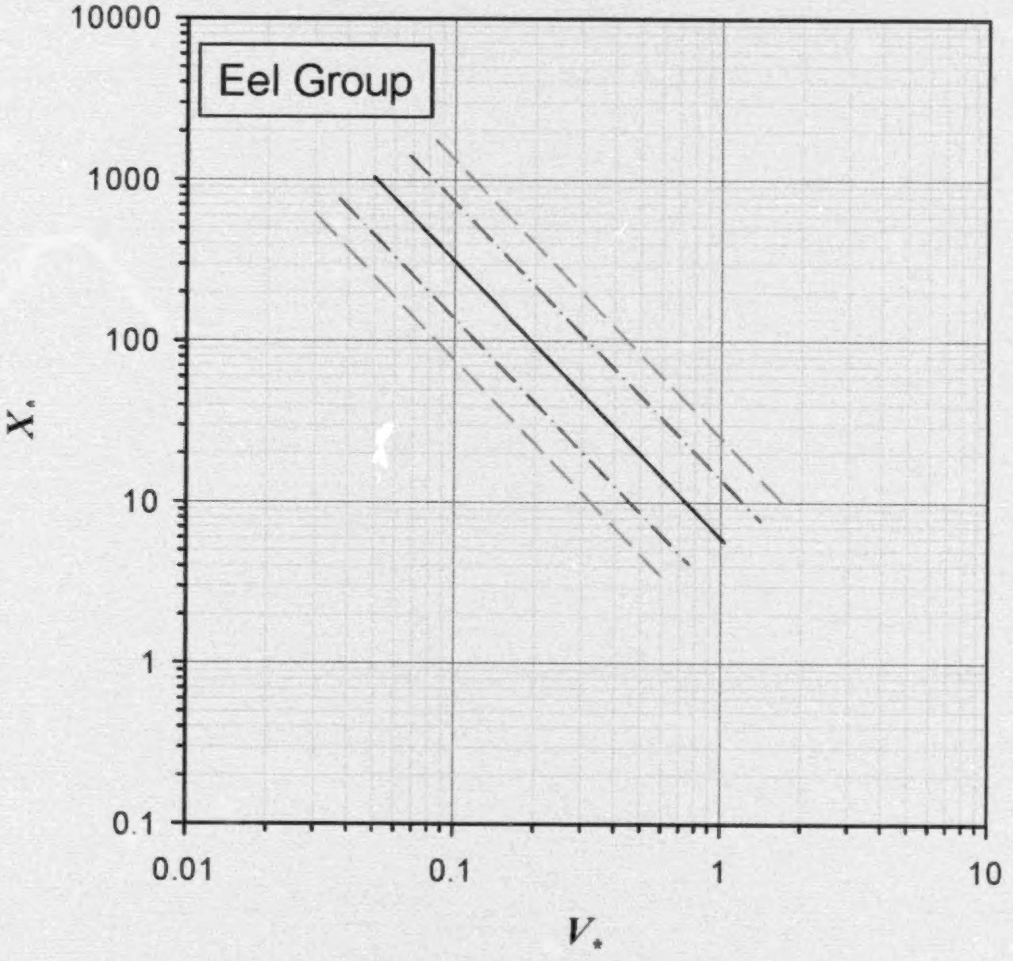


Figure I-2. Eel Group dimensionless distance plots with 75% and 95% predictionintervals derived from dimensionless endurance relationships.

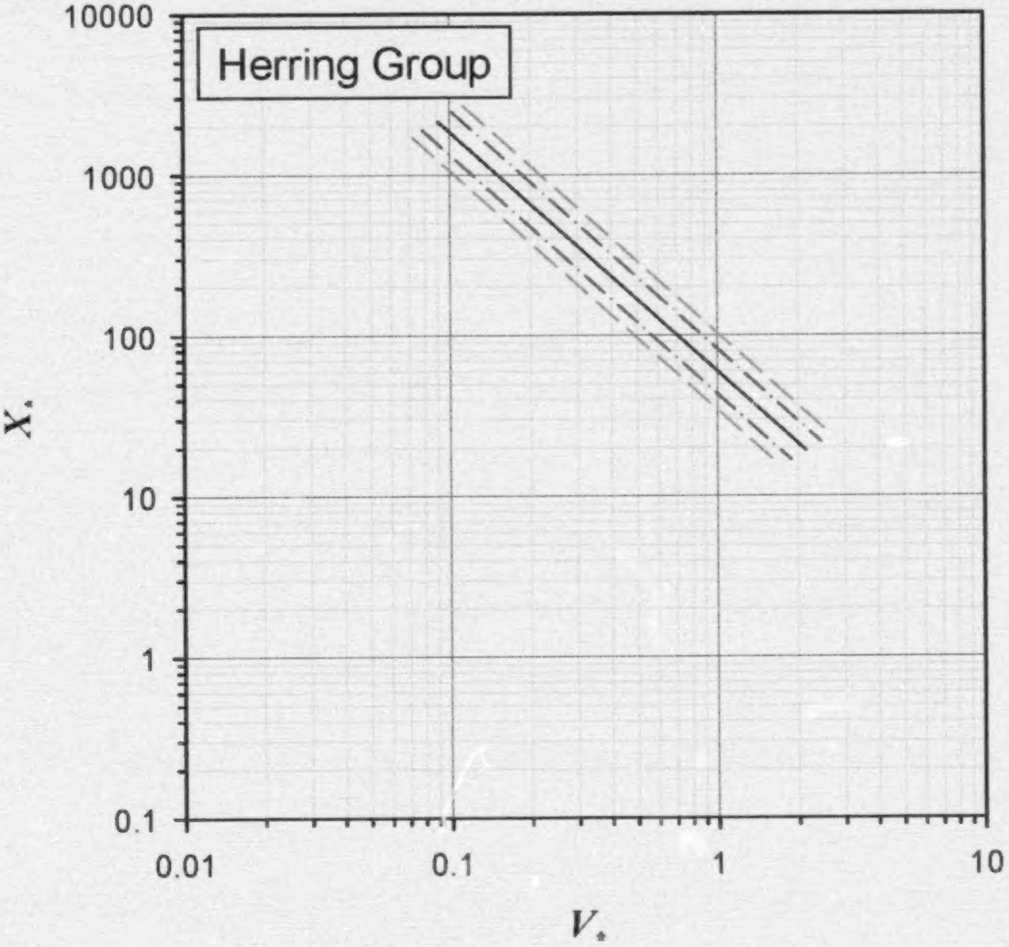


Figure I-3. Herring (Clupeidae) Group dimensionless distance plots with 75% and 95% predictionintervals derived from dimensionless endurance relationships.

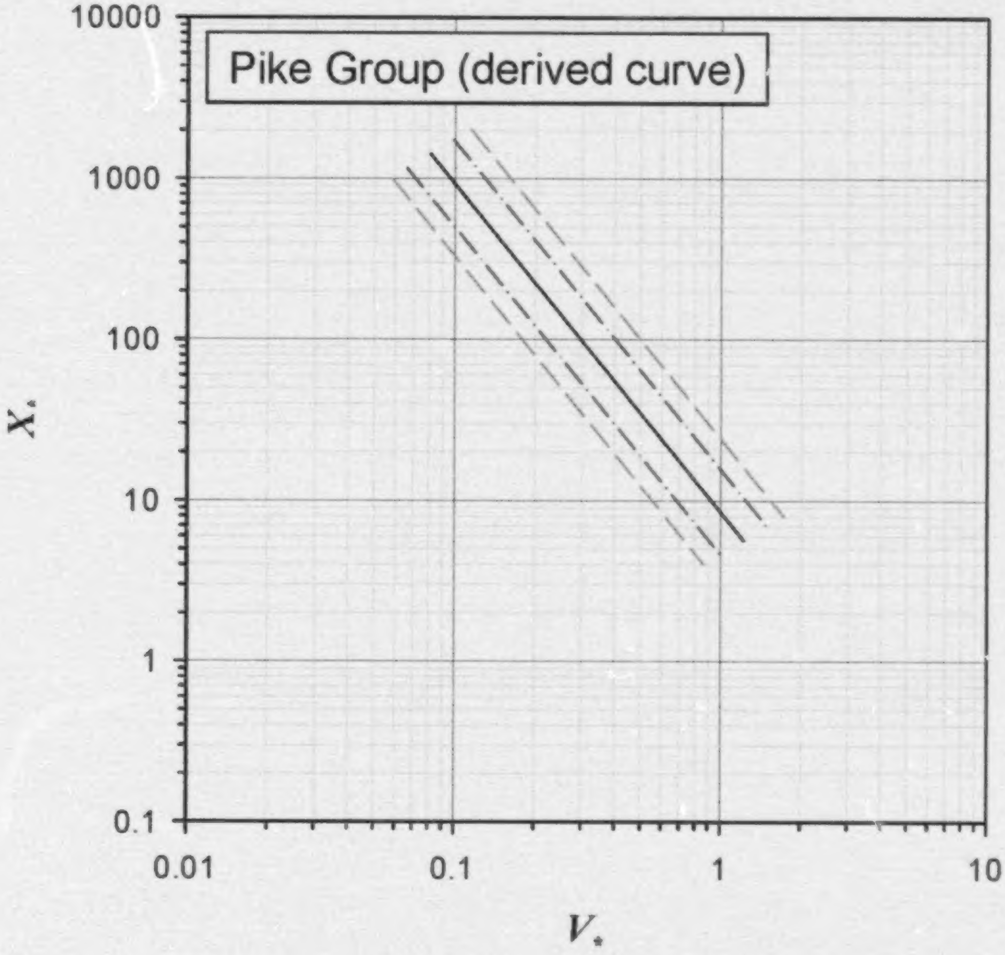


Figure I-4. Pike Group (derived curve) dimensionless distance plots with 75% and 95% predictionintervals derived from dimensionless endurance relationships.

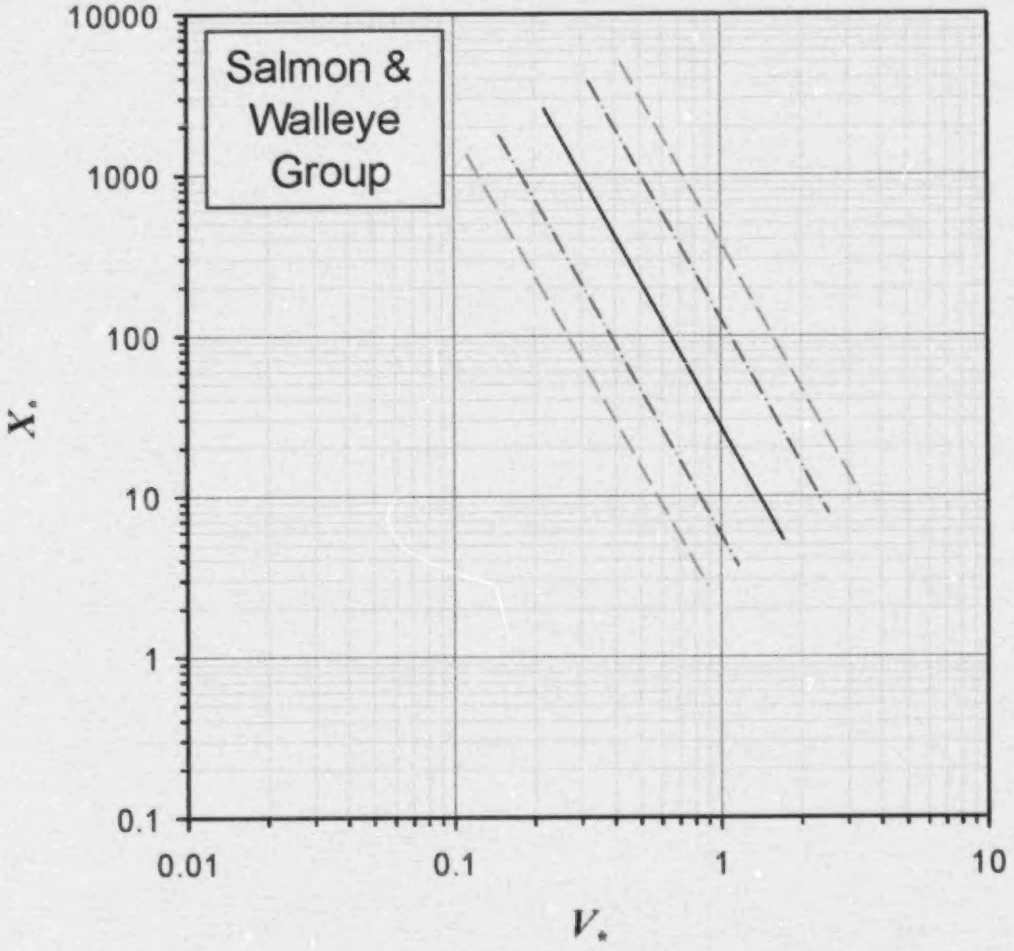


Figure I-5. Salmon and Walleye Group dimensionless distance plots with 75% and 95% predictionintervals derived from dimensionless endurance relationships.

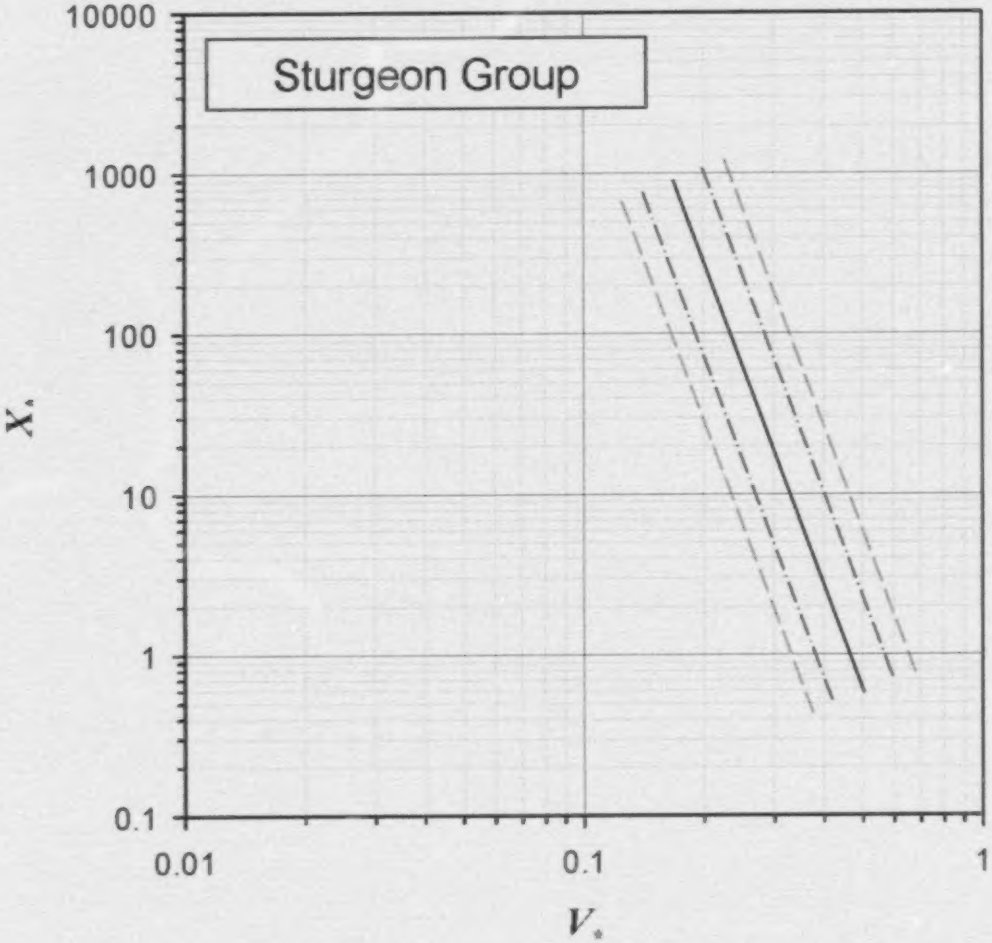


Figure I-6. Sturgeon Group dimensionless distance plots with 75% and 95% predictionintervals derived from dimensionless endurance relationships.

APPENDIX 1–SERIES J

Calculated Distance

Plotted by Group and Fish Length (18 graphs)

Swim Distance (*X; m*) vs Water Velocity (*V; m/s*)

- This section contains samples of swim distance plots (maximum swim distance as a function of water velocity) calculated for the different species groups using dimensionless distance equations and prediction intervals (Tabie A2d).
- Each graph is for a specific fish length and group. Graphs were produced for three different fish lengths, to reflect size range of data (lower, middle and upper). Dimensionless distance equations can be used to produce fatigue curves for any fish length (within the data range).
- Each plot contains 5 lines; a mean line and upper and lower 95% and 75% prediction interval lines. The mean line reflects the distance that could be achieved by 50% of the fish (for a given group and length). The lower 95% line corresponds to the distance that 95% of the fish could achieve and the upper 95% line reflects performance levels for only 5% of fish. The lower and upper 75% lines correspond to distance levels that could be achieved by 75% and 25% (respectively) of fish in the given species and length group.
- Swim distance curves correspond to endurance times that range from 3 seconds to 30 minutes.

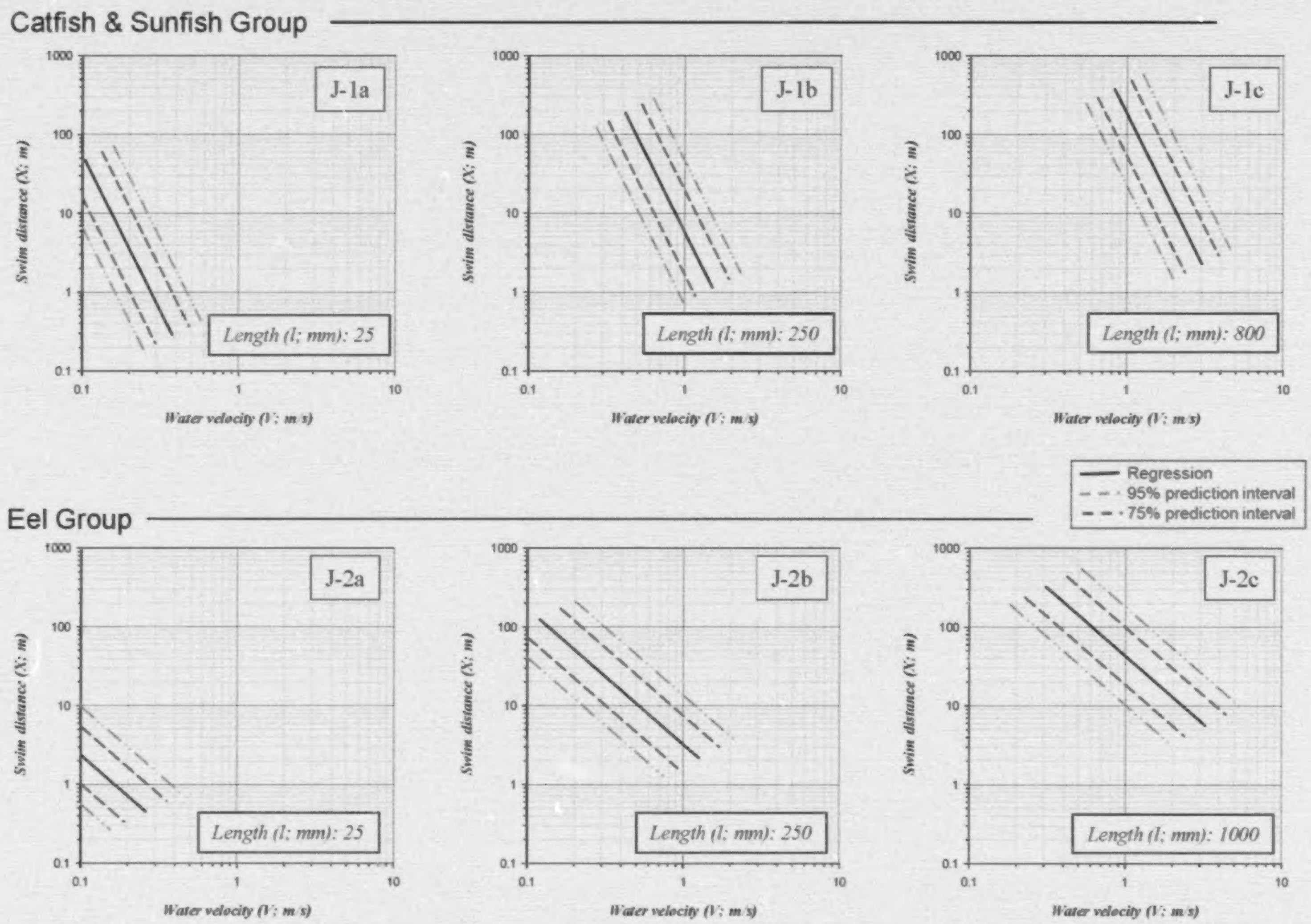


Figure J-1. Calculated Distance Data, Swim Distance (X; m) versus Water Velocity (V; m/s). Upper panel Catfish and Sunfish groups for 25, 250 and 800 mm lengths. Lower panel Eel group for 25, 250 and 1000 mm lengths.

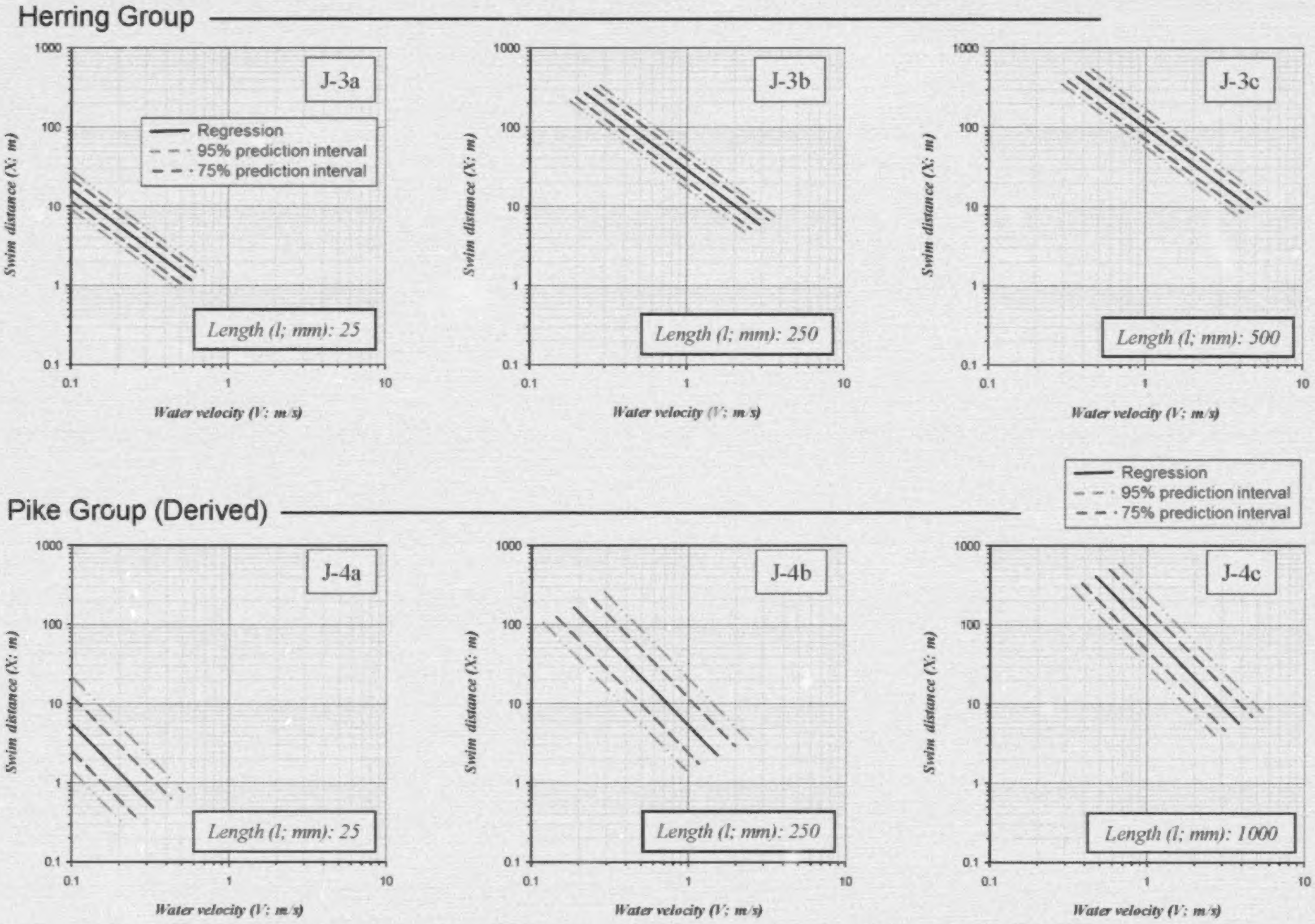


Figure J-2. Calculated Distance Data, Swim Distance (X; m) versus Water Velocity (V; m/s). Upper panel Herring group for 25, 250 and 500 mm lengths. Lower panel Pike group (derived) for 25, 250 and 1000 mm lengths.

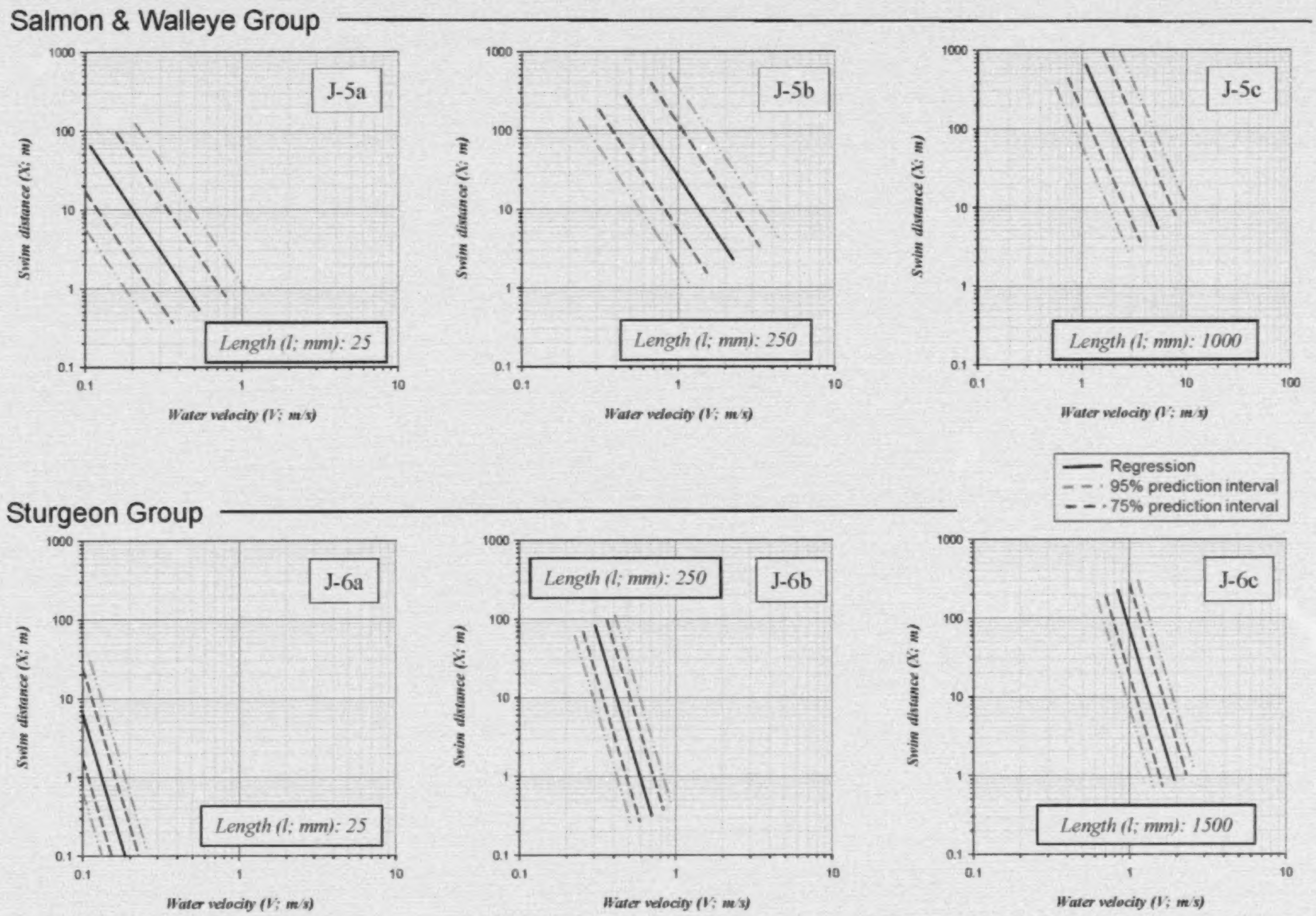


Figure J-3. Calculated Distance Data, Swim Distance (X; m) versus Water Velocity (V; m/s). Upper panel Salmon and Walleye groups for 25, 250 and 1000 mm lengths. Lower panel Pike group for 25, 250 and 1500 mm lengths.

APPENDIX 2

Data and Regression Summary Tables

APPENDIX 2–TABLE A1

Processed Endurance Data Summary Table

- Summary table of the processed endurance data that was used in the analysis. Key data parameters are summarized at various levels from individual species to groups of species. These data are reflected in various graphs presented in Appendix 1.
- Parameters that have been summarized include: fish length; water temperature; swim speed (critical swim speed for increasing velocity test); endurance time (fixed velocity test) and time step (increasing velocity test).

Table A1. Summary table of swim speed and endurance time data by grouping category and parameter.

Category parameter	Count		Fish length (l; m)					Temperature (°C)					Swim speed (U or Ucrit; m/s)					Endurance time (t; s)					Time step (□t; seconds)				
	Fish	Record	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max
Group																											
Catfish and Sunfish Group	1282	115	0.184	0.077	0.200	0.032	0.424	19.4	5.6	20.4	5.0	34.0	0.600	0.270	0.600	0.200	1.200	488	611	197	7	1656	1082	554	1200	10	1800
Clupeidae (Herring) Group	592	39	0.328	0.092	0.341	0.219	0.418	15.4	3.7	18.3	10.4	20.4	3.452	1.279	3.400	0.750	6.710	26	89	13	2	960	20	0	20	20	20
Eel Group	1747	242	0.343	0.149	0.330	0.072	0.641	13.5	4.7	12.3	5.0	23.5	1.050	0.921	0.600	0.205	3.961	234	366	84	0	1740	225	471	20	20	1800
Pike Group	138	26	0.114	0.094	0.065	0.024	0.480	17.2	3.9	19.0	12.0	25.0	0.252	0.125	0.225	0.126	0.642						380	165	300	60	600
Salmon and Walleye Group	17085	1293	0.197	0.196	0.113	0.021	0.927	13.9	5.1	13.5	3.1	32.9	1.206	1.296	0.670	0.110	9.450	426	543	171	2	1800	536	516	600	10	1800
Sturgeon Group	1008	278	0.225	0.160	0.162	0.066	1.320	14.7	5.8	15.0	5.0	25.0	0.435	0.196	0.400	0.150	1.800	186	323	62	4	1797	1459	544	1800	120	1800
Order																											
Acipenseriformes	1008	278	0.225	0.160	0.162	0.066	1.320	14.7	5.8	15.0	5.0	25.0	0.435	0.196	0.400	0.150	1.800	186	323	62	4	1797	1459	544	1800	120	1800
Anguilliformes	623	30	0.260	0.143	0.226	0.072	0.570	15.3	3.6	12.3	10.2	23.5	0.759	0.442	0.705	0.205	1.284	302	437	120	20	1740	20	0	20	20	20
Clupeiformes	592	39	0.328	0.092	0.341	0.219	0.418	15.4	3.7	18.3	10.4	20.4	3.452	1.279	3.400	0.750	6.710	26	89	13	2	960	20	0	20	20	20
Cypriniformes	6036	334	0.121	0.093	0.086	0.021	0.520	15.2	5.5	14.7	4.1	32.9	0.935	0.843	0.660	0.130	6.587	693	684	360	3	1800	238	390	20	10	1800
Esociformes	138	26	0.114	0.094	0.065	0.024	0.480	17.2	3.9	19.0	12.0	25.0	0.252	0.125	0.225	0.126	0.642						380	165	300	60	600
Gadiformes	100	60	0.296	0.135	0.247	0.120	0.630	13.8	4.0	10.0	10.0	18.0	0.753	0.450	0.460	0.339	1.910	117	156	27	0	635	600	0	600	600	600
Perciformes	1412	145	0.228	0.141	0.179	0.032	0.665	18.1	5.8	18.9	5.0	34.0	1.347	1.687	0.490	0.180	9.450	181	281	15	2	854	1070	532	1200	10	1800
Petromyzontiformes	1024	152	0.398	0.128	0.434	0.145	0.641	12.4	5.1	13.0	5.0	23.0	1.256	1.098	0.600	0.300	3.961	216	343	60	1	1635	1800	0	1800	1800	1800
Salmoniformes	10392	897	0.234	0.226	0.135	0.024	0.927	12.9	4.7	12.0	3.1	21.2	1.290	1.397	0.670	0.110	6.406	281	370	110	2	1800	680	505	600	10	1800
Siluriformes	527	34	0.226	0.044	0.202	0.052	0.277	20.5	1.3	20.5	20.0	29.6	0.791	0.208	0.700	0.600	1.200	498	617	210	7	1656	10	0	10	10	10
Family																											
Acipenseridae	1008	278	0.225	0.160	0.162	0.066	1.320	14.7	5.8	15.0	5.0	25.0	0.435	0.196	0.400	0.150	1.800	186	323	62	4	1797	1459	544	1800	120	1800
Anguillidae	623	30	0.260	0.143	0.226	0.072	0.570	15.3	3.6	12.3	10.2	23.5	0.759	0.442	0.705	0.205	1.284	302	437	120	20	1740	20	0	20	20	20
Catostomidae	1089	90	0.177	0.151	0.096	0.023	0.520	14.4	3.2	14.0	10.0	20.0	1.250	1.574	0.458	0.157	6.587	1241	830	1800	3	1800	610	229	600	300	1200
Centrarchidae	755	81	0.154	0.081	0.111	0.032	0.424	18.6	7.1	19.8	5.0	34.0	0.466	0.225	0.392	0.200	1.100	216	329	40	13	770	1097	544	1200	10	1800
Clupeidae	592	39	0.328	0.092	0.341	0.219	0.418	15.4	3.7	18.3	10.4	20.4	3.452	1.279	3.400	0.750	6.710	26	89	13	2	960	20	0	20	20	20
Cyprinidae	4947	243	0.109	0.069	0.085	0.021	0.451	15.4	5.9	15.0	4.1	32.9	0.865	0.544	0.705	0.130	2.635	523	527	360	3	1800	199	383	20	10	1800
Esocidae	138	26	0.114	0.094	0.065	0.024	0.480	17.2	3.9	19.0	12.0	25.0	0.252	0.125	0.225	0.126	0.642						380	165	300	60	600
Gadidae	100	60	0.296	0.135	0.247	0.120	0.630	13.8	4.0	10.0	10.0	18.0	0.753	0.450	0.460	0.339	1.910	117	156	27	0	635	600	0	600	600	600
Ictaluridae	527	34	0.226	0.044	0.202	0.052	0.277	20.5	1.3	20.5	20.0	29.6	0.791	0.208	0.700	0.600	1.200	498	617	210	7	1656	10	0	10	10	10
Moronidae	285	15	0.403	0.102	0.478	0.264	0.478	19.8	1.2	18.9	18.9	21.5	3.204	2.210	3.858	0.510	9.450	242	315	15	2	670					
Percidae	372	48	0.244	0.139	0.311	0.036	0.665	15.8	3.7	13.6	10.0	24.1	1.711	1.618	0.777	0.180	5.292	89	183	12	4	854	954	466	900	10	1800
Petromyzontidae	1024	152	0.398	0.128	0.434	0.145	0.641	12.4	5.1	13.0	5.0	23.0	1.256	1.098	0.600	0.300	3.961	216	343	60	1	1635	1800	0	1800	1800	1800
Salmonidae	10392	897	0.234	0.226	0.135	0.024	0.927	12.9	4.7	12.0	3.1	21.2	1.290	1.397	0.670	0.110	6.406	281	370	110	2	1800	680	505	600	10	1800
Subfamily																											
Alosinae	592	39	0.328	0.092	0.341	0.219	0.418	15.4	3.7	18.3	10.4	20.4	3.452	1.279	3.400	0.750	6.710	26	89	13	2	960	20	0	20	20	20
Catostominae	1089	90	0.177	0.151	0.096	0.023	0.520	14.4	3.2	14.0	10.0	20.0	1.250	1.574	0.458	0.157	6.587	1241	830	1800	3	1800	610	229	600	300	1200
Coregoninae	387	46	0.218	0.097	0.194	0.050	0.520	12.4	2.4	12.5	5.0	17.0	0.603	0.134	0.612	0.210	1.020	558	363	438	96	1200	766	415	600	600	1800
Salmoninae	8615	805	0.245	0.243	0.134	0.024	0.927	12.9	4.9	12.0	3.1	21.2	1.380	1.503	0.675	0.110	6.406	214	314	77	2	1800	751	490	900	10	1800
Thymallinae	1390	46	0.170	0.083	0.131	0.060	0.360	13.3	3.9	13.1	5.8	20.9	0.929	0.512	0.670	0.370	1.907	610	450	300	30	1440	120	220	20	20	600
Genus																											
Abramis	1123	14	0.082	0.003	0.082	0.074	0.093	12.4	5.1	11.7	5.9	19.3	0.563	0.278	0.455	0.305	1.310	358	200	360	60	840	20	0	20	20	20
Acipenser	951	263	0.226	0.162	0.162	0.066	1.320	14.5	5.9	15.0	5.0	25.0	0.429	0.194	0.400	0.210	1.800	189	328	63	4	1797	1467	544	1800	120	1800
Alosa	592	39	0.328	0.092	0.341	0.219	0.418	15.4	3.7	18.3	10.4	20.4	3.452	1.279	3.400	0.750	6.710	26	89	13	2	960	20	0	20	20	20

Category parameter	Count		Fish length (l; m)					Temperature (°C)					Swim speed (U or Ucrit; m/s)					Endurance time (t; s)					Time step (□t; seconds)				
	Fish	Record	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max
Anguilla	623	30	0.260	0.143	0.226	0.072	0.570	15.3	3.6	12.3	10.2	23.5	0.759	0.442	0.705	0.205	1.284	302	437	120	20	1740	20	0	20	20	20
Barbus	1178	32	0.123	0.042	0.116	0.075	0.205	13.1	4.1	12.8	7.3	22.9	1.387	0.682	0.975	0.575	2.635	636	504	540	60	1560	20	0	20	20	20
Campostoma	10	1	0.046	0.000	0.046	0.046	0.046	28.2	0.0	28.2	28.2	28.2	0.629	0.000	0.629	0.629	0.629						10	0	10	10	10
Carassius	40	7	0.101	0.000	0.101	0.101	0.101	13.0	0.0	13.0	13.0	13.0	0.798	0.300	0.765	0.410	1.300	245	321	34	3	900					
Catostomus	1063	73	0.179	0.152	0.096	0.023	0.520	14.4	3.2	14.0	10.0	20.0	1.270	1.587	0.458	0.157	6.587	1241	830	1800	3	1800	649	213	600	300	1200
Chasmistes	26	12	0.100	0.061	0.115	0.028	0.205	17.0	0.0	17.0	17.0	17.0	0.420	0.076	0.410	0.289	0.536						300	0	300	300	300
Coregonus	359	40	0.212	0.096	0.194	0.050	0.520	12.3	2.3	12.5	5.0	17.0	0.607	0.132	0.612	0.210	1.020	558	363	438	96	1200	787	436	600	600	1800
Cyprinella	63	9	0.053	0.018	0.047	0.035	0.108	22.6	4.0	23.1	17.0	27.7	0.677	0.120	0.611	0.339	0.947						93	132	10	10	300
Cyprinus	119	16	0.163	0.095	0.153	0.049	0.440	18.6	3.8	22.0	11.5	22.0	0.779	0.257	0.750	0.433	1.400	110	141	29	11	380	1238	147	1200	1200	1800
Esox	138	26	0.114	0.094	0.065	0.024	0.480	17.2	3.9	19.0	12.0	25.0	0.252	0.125	0.225	0.126	0.642						380	165	300	60	600
Etheostoma	4	1	0.036	0.000	0.036	0.036	0.036	24.1	0.0	24.1	24.1	24.1	0.400	0.000	0.400	0.400	0.400						10	0	10	10	10
Gila	215	3	0.096	0.003	0.097	0.093	0.099	22.4	2.9	20.0	20.0	26.0	0.655	0.037	0.630	0.620	0.700	120	0	120	120	120					
Gobio	16	2	0.112	0.012	0.112	0.100	0.123	15.0	0.0	15.0	15.0	15.0	0.572	0.031	0.572	0.542	0.602						1200	0	1200	1200	1200
Hybognathus	122	22	0.066	0.009	0.071	0.051	0.071	21.4	5.1	19.0	15.0	28.7	0.698	0.183	0.611	0.484	1.168	154	176	58	10	532	335	536	10	10	1200
Ictalurus	527	34	0.226	0.044	0.202	0.052	0.277	20.5	1.3	20.5	20.0	29.6	0.791	0.208	0.700	0.600	1.200	498	617	210	7	1656	10	0	10	10	10
Iotichthys	40	5	0.033	0.004	0.033	0.025	0.041	17.0	0.0	17.0	17.0	17.0	0.285	0.028	0.287	0.234	0.344						300	0	300	300	300
Lampetra	24	1	0.641	0.000	0.641	0.641	0.641	15.0	0.0	15.0	15.0	15.0	0.851	0.000	0.851	0.851	0.851						1800	0	1800	1800	1800
Lepidomeda	21	6	0.078	0.019	0.083	0.040	0.104	17.0	0.0	17.0	17.0	17.0	0.542	0.112	0.516	0.373	0.717						300	0	300	300	300
Lepomis	34	7	0.081	0.027	0.103	0.048	0.103	23.4	1.9	22.0	22.0	26.7	0.663	0.299	0.700	0.280	1.100	216	329	40	13	770	10	0	10	10	10
Leuciscus	666	33	0.131	0.053	0.132	0.050	0.202	14.0	4.7	12.6	4.1	20.9	1.114	0.316	1.156	0.450	1.556	659	620	468	32	1758	20	0	20	20	20
Lota	100	60	0.296	0.135	0.247	0.120	0.630	13.8	4.0	10.0	10.0	18.0	0.753	0.450	0.460	0.339	1.910	117	156	27	0	635	600	0	600	600	600
Luxilus	10	1	0.044	0.000	0.044	0.044	0.044	27.5	0.0	27.5	27.5	27.5	0.403	0.000	0.403	0.403	0.403						10	0	10	10	10
Lythrurus	24	2	0.039	0.006	0.045	0.033	0.045	28.2	0.9	29.0	27.2	29.0	0.473	0.086	0.550	0.381	0.550						10	0	10	10	10
Macrhybopsis	11	1	0.043	0.000	0.043	0.043	0.043	25.3	0.0	25.3	25.3	25.3	0.619	0.000	0.619	0.619	0.619						10	0	10	10	10
Micropterus	702	72	0.157	0.082	0.111	0.032	0.424	18.2	7.2	19.8	5.0	34.0	0.459	0.219	0.396	0.200	1.088						1100	522	1200	10	1800
Morone	285	15	0.403	0.102	0.478	0.264	0.478	19.8	1.2	18.9	18.9	21.5	3.204	2.210	3.858	0.510	9.450	242	315	15	2	670					
Notropis	229	24	0.042	0.005	0.042	0.035	0.052	24.0	6.1	25.9	12.0	32.9	0.515	0.166	0.497	0.219	0.814	118	124	91	11	385	60	110	10	10	300
Oncorhynchus	6077	273	0.271	0.273	0.100	0.024	0.927	12.8	5.2	12.0	3.1	20.1	1.514	1.725	0.544	0.110	6.406	184	305	10	5	1508	919	442	900	120	1800
Perca	147	19	0.107	0.025	0.095	0.050	0.178	18.5	3.9	21.0	10.0	21.0	0.410	0.215	0.396	0.180	1.130	300	257	193	31	854	1277	396	1200	900	1800
Petromyzon	1000	151	0.392	0.124	0.430	0.145	0.590	12.4	5.1	11.2	5.0	23.0	1.265	1.110	0.600	0.300	3.961	216	343	60	1	1635					
Pimephales	87	3	0.047	0.018	0.061	0.021	0.061	22.7	1.8	24.0	20.0	24.0	0.338	0.138	0.435	0.130	0.435						731	538	1200	10	1200
Platygobio	26	5	0.233	0.038	0.228	0.175	0.288	16.0	0.0	16.0	16.0	16.0	0.556	0.091	0.623	0.367	0.625						600	0	600	600	600
Pogonichthys	66	6	0.079	0.058	0.052	0.029	0.195	18.0	1.4	17.0	17.0	20.0	0.365	0.152	0.310	0.190	0.660						600	0	600	600	600
Pomoxis	19	2	0.170	0.000	0.170	0.170	0.170	25.0	0.0	25.0	25.0	25.0	0.362	0.020	0.347	0.347	0.387						1800	0	1800	1800	1800
Prosopium	9	1	0.300	0.000	0.300	0.300	0.300	10.0	0.0	10.0	10.0	10.0	0.430	0.000	0.430	0.430	0.430						600	0	600	600	600
Ptychocheilus	451	18	0.167	0.157	0.088	0.022	0.451	16.7	5.4	14.0	5.0	26.0	0.512	0.347	0.390	0.133	1.150	924	792	846	120	1800	1200	0	1200	1200	1200
Rhinichthys	67	12	0.056	0.016	0.043	0.041	0.087	20.3	3.5	17.0	17.0	24.0	0.555	0.200	0.415	0.387	0.982						300	0	300	300	300
Rutilus	354	20	0.130	0.038	0.124	0.046	0.186	14.2	3.4	14.4	8.8	18.5	1.017	0.300	1.061	0.458	1.552	867	527	893	156	1733	141	359	20	20	1200
Salmo	1734	305	0.190	0.147	0.151	0.048	0.615	12.4	4.2	12.0	4.0	21.2	1.155	0.714	1.123	0.316	4.490	204	305	99	7	1800	341	279	300	20	1200
Salvelinus	804	227	0.166	0.076	0.174	0.039	0.425	14.1	3.5	15.0	9.0	20.0	0.844	0.305	0.900	0.210	1.843	448	299	477	2	1537	683	602	600	10	1800
Sander	221	28	0.339	0.100	0.318	0.070	0.665	13.8	1.7	13.6	12.7	20.0	2.601	1.558	2.935	0.340	5.292	13	7	10	4	31	600	0	600	600	600
Scaphirhynchus	57	15	0.207	0.134	0.152	0.152	0.672	18.3	0.7	18.5	16.0	18.5	0.533	0.203	0.575	0.150	1.020	154	258	18	12	912	900	0	900	900	900
Semotilus	9	1	0.057	0.000	0.057	0.057	0.057	28.5	0.0	28.5	28.5	28.5	0.442	0.000	0.442	0.442	0.442						10	0	10	10	10
Stenodus	19	5	0.296	0.089	0.342	0.174	0.403	16.0	0.0	16.0	16.0	16.0	0.603	0.141	0.692	0.280	0.703						600	0	600	600	600
Thymallus	1390	46	0.170	0.083	0.131	0.060	0.360	13.3	3.9	13.1	5.8	20.9	0.929	0.512	0.670	0.370	1.907	610	450	300	30	1440	120	220	20	20	600

Category parameter	Count		Fish length (l; m)					Temperature (°C)					Swim speed (U or Ucrit; m/s)					Endurance time (t; s)					Time step (□t; seconds)				
	Fish	Record	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max
Species Scientific Name																											
Abramis brama	1123	14	0.082	0.003	0.082	0.074	0.093	12.4	5.1	11.7	5.9	19.3	0.563	0.278	0.455	0.305	1.310	358	200	360	60	840	20	0	20	20	20
Acipenser brevirostrum	660	130	0.163	0.032	0.156	0.066	0.211	15.0	6.2	15.0	5.0	25.0	0.358	0.065	0.350	0.210	0.450	206	353	63	16	1797	1786	92	1800	1200	1800
Acipenser fulvescens	277	132	0.372	0.236	0.363	0.120	1.320	13.4	4.9	14.0	7.0	21.0	0.592	0.283	0.500	0.258	1.800	154	264	62	4	1662	538	162	600	120	600
Acipenser transmontanus	14	1	0.342	0.000	0.342	0.342	0.342	12.0	0.0	12.0	12.0	12.0	0.564	0.000	0.564	0.564	0.564						900	0	900	900	900
Alosa aestivalis	75	10	0.219	0.000	0.219	0.219	0.219	16.9	0.0	16.9	16.9	16.9	3.548	0.971	3.601	1.799	4.870	12	13	6	3	43					
Alosa fallax	19	2	0.335	0.004	0.333	0.333	0.341	18.9	2.6	20.4	14.6	20.4	1.465	0.439	1.721	0.750	1.721	960	0	960	960	960	20	0	20	20	20
Alosa pseudoharengus	204	13	0.237	0.000	0.237	0.237	0.237	10.4	0.0	10.4	10.4	10.4	2.890	0.835	2.766	1.330	4.795	15	8	14	2	29					
Alosa sapidissima	294	14	0.418	0.000	0.418	0.418	0.418	18.3	0.0	18.3	18.3	18.3	3.945	1.359	4.155	1.669	6.710	21	22	9	3	94					
Anguilla anguilla	623	30	0.260	0.143	0.226	0.072	0.570	15.3	3.6	12.3	10.2	23.5	0.759	0.442	0.705	0.205	1.284	302	437	120	20	1740	20	0	20	20	20
Barbus barbus	1178	32	0.123	0.042	0.116	0.075	0.205	13.1	4.1	12.8	7.3	22.9	1.387	0.682	0.975	0.575	2.635	636	504	540	60	1560	20	0	20	20	20
Campostoma anomalum	10	1	0.046	0.000	0.046	0.046	0.046	28.2	0.0	28.2	28.2	28.2	0.629	0.000	0.629	0.629	0.629						10	0	10	10	10
Carassius carassius	40	7	0.101	0.000	0.101	0.101	0.101	13.0	0.0	13.0	13.0	13.0	0.798	0.300	0.765	0.410	1.300	245	321	34	3	900					
Catostomus catostomus	150	18	0.220	0.112	0.212	0.040	0.520	13.5	0.0	13.5	13.5	13.5	0.568	0.154	0.613	0.182	0.780						600	0	600	600	600
Catostomus commersoni	287	29	0.383	0.051	0.394	0.165	0.500	14.2	1.5	14.7	10.5	16.0	3.612	1.325	3.686	0.483	6.587	11	8	7	3	48	600	0	600	600	600
Catostomus laipinnis	588	26	0.064	0.026	0.061	0.024	0.114	14.6	4.1	14.0	10.0	20.0	0.351	0.118	0.337	0.157	0.663	1800	0	1800	1800	1800					
Catostomus macrocheilus	24	2	0.397	0.000	0.397	0.397	0.397	13.0	3.1	13.0	10.0	16.0	0.535	0.015	0.535	0.520	0.550						1200	0	1200	1200	1200
Catostomus platyrhynchus	14	3	0.025	0.002	0.025	0.023	0.029	17.0	0.0	17.0	17.0	17.0	0.641	0.141	0.629	0.507	0.832						300	0	300	300	300
Chasmistes liorus	26	12	0.100	0.061	0.115	0.028	0.205	17.0	0.0	17.0	17.0	17.0	0.420	0.076	0.410	0.289	0.536						300	0	300	300	300
Coregonus artedii	28	2	0.135	0.000	0.135	0.135	0.135	12.0	0.0	12.0	12.0	12.0	0.581	0.079	0.630	0.458	0.630	438	0	438	438	438	1800	0	1800	1800	1800
Coregonus autumnalis	4	1	0.420	0.000	0.420	0.420	0.420	10.0	0.0	10.0	10.0	10.0	0.800	0.000	0.800	0.800	0.800						600	0	600	600	600
Coregonus clupeaformis	304	26	0.216	0.096	0.194	0.070	0.520	12.3	2.5	13.5	5.0	17.0	0.619	0.130	0.614	0.260	1.020	579	390	852	96	1200	771	420	600	600	1800
Coregonus nasus	21	10	0.206	0.096	0.200	0.050	0.330	12.5	0.0	12.5	12.5	12.5	0.437	0.086	0.470	0.210	0.660						600	0	600	600	600
Coregonus sardinella	2	1	0.300	0.000	0.300	0.300	0.300	16.0	0.0	16.0	16.0	16.0	0.600	0.000	0.600	0.600	0.600						600	0	600	600	600
Cyprinella lutrensis	16	1	0.043	0.000	0.043	0.043	0.043	27.7	0.0	27.7	27.7	27.7	0.712	0.000	0.712	0.712	0.712						10	0	10	10	10
Cyprinella proserpina	10	1	0.040	0.000	0.040	0.040	0.040	23.5	0.0	23.5	23.5	23.5	0.608	0.000	0.608	0.608	0.608						10	0	10	10	10
Cyprinella venusta	19	1	0.047	0.000	0.047	0.047	0.047	23.1	0.0	23.1	23.1	23.1	0.611	0.000	0.611	0.611	0.611						10	0	10	10	10
Cyprinus carpio	119	16	0.163	0.095	0.153	0.049	0.440	18.6	3.8	22.0	11.5	22.0	0.779	0.257	0.750	0.433	1.400	110	141	29	11	380	1238	147	1200	1200	1800
Esox lucius	128	25	0.108	0.095	0.065	0.024	0.480	16.5	3.4	19.0	12.0	19.0	0.221	0.063	0.225	0.126	0.435						405	144	300	300	600
Esox sp.	10	1	0.189	0.000	0.189	0.189	0.189	25.0	0.0	25.0	25.0	25.0	0.642	0.000	0.642	0.642	0.642						60	0	60	60	60
Etheostoma grahami	4	1	0.036	0.000	0.036	0.036	0.036	24.1	0.0	24.1	24.1	24.1	0.400	0.000	0.400	0.400	0.400						10	0	10	10	10
Gila cypha	156	2	0.096	0.003	0.099	0.093	0.099	23.3	3.0	26.0	20.0	26.0	0.668	0.035	0.700	0.630	0.700	120	0	120	120	120					
Gila elegans	59	1	0.097	0.000	0.097	0.097	0.097	20.0	0.0	20.0	20.0	20.0	0.620	0.000	0.620	0.620	0.620	120	0	120	120	120					
Gobio gobio	16	2	0.112	0.012	0.112	0.100	0.123	15.0	0.0	15.0	15.0	15.0	0.572	0.031	0.572	0.542	0.602						1200	0	1200	1200	1200
Hybognathus amarus	90	21	0.071	0.001	0.071	0.069	0.071	18.9	3.1	19.0	15.0	23.0	0.728	0.204	0.643	0.484	1.168	154	176	58	10	532	1200	0	1200	1200	1200
Hybognathus placitus	32	1	0.051	0.000	0.051	0.051	0.051	28.7	0.0	28.7	28.7	28.7	0.611	0.000	0.611	0.611	0.611						10	0	10	10	10
Ictalurus furcatus	183	8	0.234	0.058	0.277	0.052	0.277	20.7	2.2	20.0	20.0	29.6	0.706	0.159	0.600	0.600	1.100	300	173	432	17	432	10	0	10	10	10
Ictalurus punctatus	274	20	0.228	0.036	0.202	0.200	0.276	20.3	0.2	20.5	20.0	20.5	0.801	0.211	0.700	0.600	1.200	725	762	197	7	1656					
Ictalurus punctatus x furcatus	70	6	0.200	0.000	0.200	0.200	0.200	20.5	0.0	20.5	20.5	20.5	0.974	0.180	1.000	0.700	1.200	99	80	70	26	252					
Iotichthys phlegethontis	40	5	0.033	0.004	0.033	0.025	0.041	17.0	0.0	17.0	17.0	17.0	0.285	0.028	0.287	0.234	0.344						300	0	300	300	300
Lampetra tridentata	24	1	0.641	0.000	0.641	0.641	0.641	15.0	0.0	15.0	15.0	15.0	0.851	0.000	0.851	0.851	0.851						1800	0	1800	1800	1800
Lepidomeda aliciae	21	6	0.078	0.019	0.083	0.040	0.104	17.0	0.0	17.0	17.0	17.0	0.542	0.112	0.516	0.373	0.717						300	0	300	300	300
Lepomis auritus	5	1	0.048	0.000	0.048	0.048	0.048	26.7	0.0	26.7	26.7	26.7	0.354	0.000	0.354	0.354	0.354						10	0	10	10	10
Lepomis incisor	20	4	0.103	0.000	0.103	0.103	0.103	22.0	0.0	22.0	22.0	22.0	0.888	0.155	0.875	0.700	1.100	216	329	40	13	770					
Lepomis macrochirus	4	1	0.050	0.000	0.050	0.050	0.050	25.3	0.0	25.3	25.3	25.3	0.405	0.000	0.405	0.405	0.405						10	0	10	10	10

Category parameter	Count		Fish length (l; m)					Temperature (°C)					Swim speed (U or Ucrit; m/s)					Endurance time (t; s)					Time step (□t; seconds)				
	Fish	Record	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max
Lepomis megalotis	5	1	0.049	0.000	0.049	0.049	0.049	24.4	0.0	24.4	24.4	24.4	0.280	0.000	0.280	0.280	0.280						10	0	10	10	10
Leuciscus cephalus	304	14	0.120	0.055	0.123	0.050	0.202	13.3	4.1	11.8	8.4	20.0	1.156	0.286	1.243	0.650	1.556	161	109	120	66	360	20	0	20	20	20
Leuciscus leuciscus	362	19	0.141	0.049	0.135	0.050	0.192	14.6	5.1	13.5	4.1	20.9	1.079	0.335	0.987	0.450	1.547	920	619	542	32	1758	20	0	20	20	20
Lota lota	100	60	0.296	0.135	0.247	0.120	0.630	13.8	4.0	10.0	10.0	18.0	0.753	0.450	0.460	0.339	1.910	117	156	27	0	635	600	0	600	600	600
Luxilus chrysocephalus	10	1	0.044	0.000	0.044	0.044	0.044	27.5	0.0	27.5	27.5	27.5	0.403	0.000	0.403	0.403	0.403						10	0	10	10	10
Lythrurus fumeus	11	1	0.033	0.000	0.033	0.033	0.033	27.2	0.0	27.2	27.2	27.2	0.381	0.000	0.381	0.381	0.381						10	0	10	10	10
Lythrurus umbratilis	13	1	0.045	0.000	0.045	0.045	0.045	29.0	0.0	29.0	29.0	29.0	0.550	0.000	0.550	0.550	0.550						10	0	10	10	10
Macrhybopsis aestivalis	11	1	0.043	0.000	0.043	0.043	0.043	25.3	0.0	25.3	25.3	25.3	0.619	0.000	0.619	0.619	0.619						10	0	10	10	10
Micropterus dolomieu	117	14	0.300	0.064	0.311	0.123	0.424	18.2	1.5	17.0	13.5	20.3	0.879	0.169	0.906	0.271	1.088						1026	713	600	300	1800
Micropterus salmoides	585	58	0.128	0.048	0.104	0.032	0.260	18.2	7.9	20.0	5.0	34.0	0.375	0.098	0.392	0.200	0.650						1114	474	1200	10	1800
Morone americana	100	1	0.264	0.000	0.264	0.264	0.264	21.5	0.0	21.5	21.5	21.5	0.510	0.000	0.510	0.510	0.510	670	0	670	670	670					
Morone saxatilis	185	14	0.478	0.000	0.478	0.478	0.478	18.9	0.0	18.9	18.9	18.9	4.660	1.209	4.284	2.185	9.450	11	5	9	2	23					
Notropis amabilis	29	1	0.042	0.000	0.042	0.042	0.042	23.4	0.0	23.4	23.4	23.4	0.636	0.000	0.636	0.636	0.636						10	0	10	10	10
Notropis atherinoides	10	1	0.042	0.000	0.042	0.042	0.042	30.0	0.0	30.0	30.0	30.0	0.814	0.000	0.814	0.814	0.814						10	0	10	10	10
Notropis atrocaudalis	11	1	0.050	0.000	0.050	0.050	0.050	26.7	0.0	26.7	26.7	26.7	0.469	0.000	0.469	0.469	0.469						10	0	10	10	10
Notropis bairdi	10	1	0.044	0.000	0.044	0.044	0.044	25.8	0.0	25.8	25.8	25.8	0.456	0.000	0.456	0.456	0.456						10	0	10	10	10
Notropis buccula	10	1	0.036	0.000	0.036	0.036	0.036	32.9	0.0	32.9	32.9	32.9	0.497	0.000	0.497	0.497	0.497						10	0	10	10	10
Notropis buchanani	12	1	0.035	0.000	0.035	0.035	0.035	25.9	0.0	25.9	25.9	25.9	0.447	0.000	0.447	0.447	0.447						10	0	10	10	10
Notropis hudsonius	32	2	0.051	0.002	0.051	0.049	0.052	12.0	0.0	12.0	12.0	12.0	0.220	0.001	0.220	0.219	0.221						300	0	300	300	300
Notropis oxyrhynchus	10	1	0.040	0.000	0.040	0.040	0.040	32.9	0.0	32.9	32.9	32.9	0.534	0.000	0.534	0.534	0.534						10	0	10	10	10
Notropis sabinae	12	1	0.038	0.000	0.038	0.038	0.038	27.4	0.0	27.4	27.4	27.4	0.469	0.000	0.469	0.469	0.469						10	0	10	10	10
Notropis shumardi	10	1	0.042	0.000	0.042	0.042	0.042	30.5	0.0	30.5	30.5	30.5	0.794	0.000	0.794	0.794	0.794						10	0	10	10	10
Notropis stramineus	18	1	0.043	0.000	0.043	0.043	0.043	28.4	0.0	28.4	28.4	28.4	0.665	0.000	0.665	0.665	0.665						10	0	10	10	10
Notropis texanus	7	1	0.041	0.000	0.041	0.041	0.041	27.3	0.0	27.3	27.3	27.3	0.387	0.000	0.387	0.387	0.387						10	0	10	10	10
Notropis topeka	43	10	0.040	0.005	0.037	0.037	0.050	20.0	0.0	20.0	20.0	20.0	0.559	0.113	0.567	0.400	0.750	118	124	91	11	385					
Notropis volucellus	15	1	0.035	0.000	0.035	0.035	0.035	27.8	0.0	27.8	27.8	27.8	0.436	0.000	0.436	0.436	0.436						10	0	10	10	10
Oncorhynchus clarki	161	7	0.099	0.055	0.088	0.038	0.240	17.8	2.0	19.0	13.0	19.0	0.578	0.148	0.585	0.277	0.900	272	0	272	272	272	734	269	900	300	900
Oncorhynchus gorbuscha	588	19	0.188	0.217	0.033	0.031	0.574	9.0	3.8	10.0	4.0	20.0	0.518	0.508	0.192	0.136	2.380	300	378	95	35	1508	1372	450	1800	900	1800
Oncorhynchus keta	445	20	0.039	0.002	0.039	0.038	0.048	7.1	2.5	7.0	4.0	10.0	0.177	0.042	0.174	0.126	0.291	436	325	355	75	900	851	165	900	300	900
Oncorhynchus kisutch	549	60	0.218	0.244	0.081	0.034	0.750	11.9	4.6	10.4	7.0	20.1	1.024	1.166	0.550	0.131	4.059	142	145	94	6	714	939	336	900	600	1800
Oncorhynchus mykiss: rainbow	1217	60	0.116	0.116	0.098	0.024	0.410	11.1	3.5	10.5	6.0	18.5	0.408	0.315	0.390	0.110	1.470	538	417	425	18	1278	763	544	900	120	1800
Oncorhynchus mykiss: steelhead	1867	54	0.450	0.271	0.622	0.028	0.820	16.4	4.1	19.0	7.0	19.0	2.751	1.772	3.327	0.115	6.406	89	223	6	5	900	872	147	900	120	900
Oncorhynchus nerka	36	7	0.308	0.200	0.176	0.138	0.621	15.1	3.1	15.0	10.0	18.0	1.301	0.739	0.829	0.662	2.268	353	193	360	196	942					
Oncorhynchus tshawytscha	1214	46	0.325	0.303	0.140	0.038	0.927	12.9	6.0	13.0	3.1	19.0	2.047	1.999	0.551	0.140	6.223	90	188	6	5	900	968	233	900	900	1800
Perca flavescens	131	17	0.103	0.019	0.095	0.050	0.151	18.9	4.0	21.0	10.0	21.0	0.342	0.077	0.379	0.180	0.427	300	257	193	31	854	1292	433	900	900	1800
Perca fluviatilis	16	2	0.140	0.040	0.140	0.101	0.178	15.0	0.0	15.0	15.0	15.0	0.968	0.168	0.968	0.806	1.130						1200	0	1200	1200	1200
Petromyzon marinus	1000	151	0.392	0.124	0.430	0.145	0.590	12.4	5.1	11.2	5.0	23.0	1.265	1.110	0.600	0.300	3.961	216	343	60	1	1635					
Pimephales promelas	75	2	0.047	0.019	0.061	0.021	0.061	22.6	1.9	24.0	20.0	24.0	0.329	0.146	0.435	0.130	0.435						846	489	1200	180	1200
Pimephales vigilax	12	1	0.050	0.000	0.050	0.050	0.050	23.4	0.0	23.4	23.4	23.4	0.396	0.000	0.396	0.396	0.396						10	0	10	10	10
Platygobio gracilus	26	5	0.233	0.038	0.228	0.175	0.288	16.0	0.0	16.0	16.0	16.0	0.556	0.091	0.623	0.367	0.625						600	0	600	600	600
Pogonichthys macrolepidotus	66	6	0.079	0.058	0.052	0.029	0.195	18.0	1.4	17.0	17.0	20.0	0.365	0.152	0.310	0.190	0.660						600	0	600	600	600
Pomoxis annularis	19	2	0.170	0.000	0.170	0.170	0.170	25.0	0.0	25.0	25.0	25.0	0.362	0.020	0.347	0.347	0.387						1800	0	1800	1800	1800
Prosopium williamsoni	9	1	0.300	0.000	0.300	0.300	0.300	10.0	0.0	10.0	10.0	10.0	0.430	0.000	0.430	0.430	0.430						600	0	600	600	600
Ptychocheilus lucius	345	11	0.111	0.133	0.088	0.022	0.451	17.4	5.6	14.0	10.0	26.0	0.406	0.301	0.390	0.133	1.080	870	836	120	120	1800					
Ptychocheilus oregonensis	106	7	0.350	0.061	0.355	0.250	0.435	14.5	3.8	16.0	5.0	18.0	0.856	0.249	1.000	0.484	1.150	1242	299	1224	846	1662	1200	0	1200	1200	1200

Category parameter	Count		Fish length (l; m)					Temperature (°C)					Swim speed (U or Ucrit; m/s)					Endurance time (t; s)					Time step (□t; seconds)				
	Fish	Record	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max
Rhinichthys atratulus	32	1	0.043	0.000	0.043	0.043	0.043	24.0	0.0	24.0	24.0	24.0	0.387	0.000	0.387	0.387	0.387						300	0	300	300	300
Rhinichthys cataractae	15	6	0.066	0.016	0.070	0.041	0.087	17.0	0.0	17.0	17.0	17.0	0.727	0.205	0.657	0.415	0.982						300	0	300	300	300
Rhinichthys osculus	20	5	0.071	0.011	0.077	0.048	0.085	17.0	0.0	17.0	17.0	17.0	0.694	0.127	0.749	0.485	0.806						300	0	300	300	300
Richardsonius balteatus	18	6	0.074	0.022	0.079	0.035	0.108	17.0	0.0	17.0	17.0	17.0	0.755	0.192	0.841	0.339	0.947						300	0	300	300	300
Rutilus rutilus	354	20	0.130	0.038	0.124	0.046	0.186	14.2	3.4	14.4	8.8	18.5	1.017	0.300	1.061	0.458	1.552	867	527	893	156	1733	141	359	20	20	1200
Salmo salar	1065	145	0.213	0.173	0.162	0.048	0.615	13.1	3.5	12.0	4.0	20.5	1.199	0.842	1.086	0.380	4.490	164	224	99	7	1800	430	187	600	120	600
Salmo trutta	669	160	0.153	0.076	0.131	0.048	0.400	11.4	4.8	11.8	5.0	21.2	1.085	0.431	1.220	0.316	1.788	315	441	119	11	1652	245	326	20	20	1200
Salvelinus alpinus	154	30	0.227	0.084	0.188	0.077	0.401	11.1	2.4	10.0	9.0	15.0	0.901	0.187	1.000	0.330	1.300	616	286	734	11	1028	664	124	600	600	900
Salvelinus confluentus	106	16	0.207	0.046	0.190	0.109	0.425	12.3	2.9	15.0	9.0	15.0	0.977	0.193	1.000	0.272	1.150	598	60	636	494	647	1800	0	1800	1800	1800
Salvelinus fontinalis	454	177	0.129	0.063	0.112	0.039	0.405	15.9	2.9	16.7	9.5	20.0	0.755	0.348	0.610	0.210	1.843	261	324	158	2	1537	612	605	300	10	1800
Salvelinus namaycush	90	4	0.202	0.021	0.189	0.175	0.225	12.3	3.0	15.0	9.0	15.0	1.044	0.102	1.000	0.900	1.150	538	58	538	473	603					
Sander vitreus	221	28	0.339	0.100	0.318	0.070	0.665	13.8	1.7	13.6	12.7	20.0	2.601	1.558	2.935	0.340	5.292	13	7	10	4	31	600	0	600	600	600
Scaphirhynchus albus	52	13	0.166	0.016	0.152	0.152	0.184	18.5	0.0	18.5	18.5	18.5	0.492	0.161	0.500	0.150	0.680	154	258	18	12	912					
Scaphirhynchus platorynchus	5	2	0.631	0.056	0.672	0.570	0.672	16.0	0.0	16.0	16.0	16.0	0.953	0.061	0.909	0.909	1.020						900	0	900	900	900
Semotilus atromaculatus	9	1	0.057	0.000	0.057	0.057	0.057	28.5	0.0	28.5	28.5	28.5	0.442	0.000	0.442	0.442	0.442						10	0	10	10	10
Stenodus leucichthys	19	5	0.296	0.089	0.342	0.174	0.403	16.0	0.0	16.0	16.0	16.0	0.603	0.141	0.692	0.280	0.703						600	0	600	600	600
Thymallus arcticus	89	12	0.227	0.071	0.252	0.060	0.360	16.0	0.0	16.0	16.0	16.0	0.673	0.058	0.694	0.500	0.835						600	0	600	600	600
Thymallus thymallus	1301	34	0.166	0.083	0.113	0.082	0.312	13.1	4.0	12.8	5.8	20.9	0.946	0.525	0.670	0.370	1.907	610	450	300	30	1440	20	0	20	20	20

APPENDIX 2–TABLE A2A-D

Regression and Prediction Interval Summary Tables

- This series of tables presents a summary of the regression results that were calculated using the processed endurance data collection. Four different tables have been produced:
    1) least squares regression analysis using traditional swim speed in body lengths per second versus time-to-fatigue in seconds;
    2) least squares regression analysis using dimensionless swim speed versus dimensionless endurance time parameters;
    3) Deming regression analysis using traditional swim speed in body lengths per second versus time-to-fatigue in seconds; and
    4) Deming regression analysis using dimensionless swim speed versus dimensionless endurance time parameters.
- Regression results in the tables are presented based on a hierarchical arrangement with group (combination of species) at the upper level and the corresponding collection of species presented below the group at various taxonomic levels. The least squares dimensionless endurance table includes regression results at species level where data were adequate to produce a relationship (some relationships are limited in terms of defining the overall fatigue curve and these have been noted in the table). The same table format was used for all four tables; however, the results for only a select set of species and groups are present in Tables A2b-d and these were produced to evaluate the different parameters and regression methods during the data analysis process. More details are in the report.
- These tables also include coefficients for dimensionless distance equations that were derived from the dimensionless endurance regression results. The upper and lower 75% and 95% prediction interval coefficients are provided.

Endurance equations (dimensionless and body lengths per second):

$$U_* = Kt_*^b \text{ and } U/l = Kt^b$$

Distance equations (dimensionless and distance-velocity):

$$X_* = MV_*^a \text{ and } X = MV^a$$

Table A2a. Summary of least squares regressions for dimensionless fatigue curves (U versus t*) with 95% and 75% prediction intervals by group and taxonomy. Missing results correspond to limited data which prevented meaningful regressions. Taxonomic classification is from the Integrated Taxonomic Information System - ITIS.*

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Linear Regression U_* vs t_*						X_* vs V_* Equation		Comment	95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	RMSE	p	n	M	a		K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
Catfish and Sunfish Group							2.1027	-0.1977	0.6428	0.2198	<.0001	1282	3.4725	-4.0592	Limited burst	3.2403	-0.1978	30.8777	-4.0563	1.3644	-0.1975	0.3896	-4.0621	2.7099	-0.1977	12.5168	-4.0575	1.6315	-0.1976	0.9626	-4.0609
		Perciformes– some families are grouped with the Salmon and Walleye Group due to swimming performance																													
			Centrarchidae				1.7459	-0.1772	0.311	0.268	<.0001	755	1.6642	-4.6449		2.9814	-0.1781	33.2270	-4.6153	1.0224	-0.1762	0.0807	-4.6749	2.3895	-0.1777	9.6692	-4.6275	1.2757	-0.1766	0.2833	-4.6624
					Lepomis		0.5979	0.0239	0.010	0.335	0.5654	34	-1.9979E+07	42.9180		1.1344	0.0344	-0.0003	30.0500	0.3152	0.0133	-2.6377E+35	76.2516	0.8642	0.0299	-1.4227	34.4065	0.4137	0.0178	-2.3593E+19	57.2496
						Lepomis auritus; Redbreast Sunfish						5																			
						Lepomis incisor; Sunfish	1.6467	-0.1004	0.867	0.066	<.0001	20	5.5916	-8.9595	Prolonged	1.8844	-0.0988	23.2865	0.6336	1.4391	-0.1020	1.4036	-8.8055	1.7773	-0.0995	12.4642	-9.0488	1.5258	-0.1013	2.5444	-8.8718
						Lepomis macrochirus; Bluegill						4																			
						Lepomis megalotis; Longear Sunfish						5																			
					Micropterus		1.8347	-0.1827	0.210	0.259	<.0001	702	2.0522	-4.4721	Mostly prolonged	3.0870	-0.1839	34.2656	-4.4377	1.0905	-0.1816	0.1186	-4.5069	2.4893	-0.1834	10.7407	-4.4519	1.3523	-0.1821	0.3873	-4.4925
						Micropterus dolomieu; Smallmouth Bass						117				2.2493	-0.1435	16.1512	0.8106	1.2615	-0.1446	0.2861	-5.9158	1.9942	-0.1438	6.9416	-5.9564	1.4229	-0.1444	0.6592	-5.9264
						Micropterus salmoides; Largemouth Bass						585				1.5953	-0.1191	2.3555	0.4671	0.5806	-0.1146	0.0004	-7.7265	1.2943	-0.1181	0.4104	-7.4642	0.7156	-0.1155	0.0025	-7.6565
					Pomoxis							19				0.3143	0.0000			0.2489	0.0000			0.2988	0.0000			0.2619	0.0000		
						Pomoxis annularis; White Crappie						19				0.3143	0.0000		-1.1574	0.2489	0.0000			0.2988	0.0000			0.2619	0.0000		
		Siluriformes										527				2.8333	-0.2059	13.2979	-3.8557	1.7784	-0.2058	1.3879	-3.8599	2.5730	-0.2059	8.3344	-3.8565	1.9583	-0.2058	2.2159	-3.8590
			Ictaluridae									527				2.8333	-0.2059	13.2979	-3.8557	1.7784	-0.2058	1.3879	-3.8599	2.5730	-0.2059	8.3344	-3.8565	1.9583	-0.2058	2.2159	-3.8590
					Ictalurus		2.2447	-0.2059	0.870	0.118	<.0001	527	4.2982	-3.8578	Mostly prolonged	2.8333	-0.2059	13.2979	-3.8557	1.7784	-0.2058	1.3879	-3.8599	2.5730	-0.2059	8.3344	-3.8565	1.9583	-0.2058	2.2159	-3.8590
						Ictalurus furcatus; Blue Catfish	3.3383	-0.2789	0.953	0.070	<.0001	183	9.0280	-2.5860	Mostly prolonged	3.8476	-0.2793	14.9434	1.3474	2.8965	-0.2785	5.4465	-2.5911	3.6273	-0.2791	12.1247	-2.5830	3.0723	-0.2786	6.7189	-2.5890
						Ictalurus punctatus; Channel Catfish	1.9929	-0.1823	0.975	0.050	<.0001	274	3.2489	-4.4863	Mostly prolonged	2.2021	-0.1823	5.6101	0.7894	1.8036	-0.1822	1.8807	-4.4885	2.1129	-0.1823	4.4738	-4.4850	1.8798	-0.1822	2.3590	-4.4876
						Ictalurus punctatus x furcatus; Channel x blue hybrid	2.9844	-0.2366	0.978	0.029	<.0001	70	10.0616	-3.2265	Mostly prolonged	3.1597	-0.2364	12.8445	1.1505	2.8187	-0.2368	7.8847	-3.2233	3.0851	-0.2365	11.5961	-3.2284	2.8869	-0.2367	8.7314	-3.2246
Clupeidae (Herring) Group							9.8756	-0.3961	0.9050	0.1208	<.0001	592	59.5439	-1.5247	Lacking prolonged	12.5091	-0.3958	108.5677	-1.5266	7.7966	-0.3964	32.6864	-1.5228	11.3437	-0.3959	84.6706	-1.5258	8.5976	-0.3963	41.8867	-1.5236
		Clupeiformes																													
			Clupeidae																												
				Alosinae																											
					Alosa		9.8756	-0.3961	0.9050	0.1208	<.0001	592	59.5439	-1.5247	Mostly burst	12.5091	-0.3958	108.5677	-1.5266	7.7966	-0.3964	32.6864	-1.5228	11.3437	-0.3959	84.6706	-1.5258	8.5976	-0.3963	41.8867	-1.5236
						Alosa aestivalis; Blueback Herring	10.0053	-0.3672	0.9631	0.0613	<.0001	75	88.4393	-1.7237	Mostly burst	11.2851	-0.3663	124.2218	2.4235	8.8707	-0.3680	63.0595	-1.7176	10.7311	-0.3667	107.7494	-1.7272	9.3286	-0.3676	72.6271	-1.7201
						Alosa fallax; Twaite Shad						19	7.8380	-3.5810		2.6490	-0.2183	7.8380	0.9742	2.6490	-0.2183	7.8380	-3.5810	2.6490	-0.2183	7.8380	-3.5810	2.6490	-0.2183	7.8380	-3.5810
						Alosa pseudoharengus; Alewife	11.1267	-0.4137	0.8919	0.0979	<.0001	204	65.6427	-1.4170	Mostly burst	13.5638	-0.4146	104.7979	2.6074	9.1274	-0.4128	41.0332	-1.4223	12.4938	-0.4143	86.3304	-1.4139	9.9092	-0.4132	49.8776	-1.4201
						Alosa sapidissima; American Shad	9.6080	-0.3997	0.9833	0.0501	<.0001	294	53.3972	-1.5022	Mostly burst	10.6044	-0.3996	68.3928	2.3613	8.7052	-0.3997	41.6923	-1.5018	10.1796	-0.3996	61.7260	-1.5024	9.0685	-0.3997	46.1933	-1.5020
Eel Group							3.5571	-0.3595	0.8438	0.2844	<.0001	1747	5.5470	-1.7820	Comprehensive dataset	6.2174	-0.3595	26.2162	-1.7817	2.0351	-0.3594	1.1733	-1.7823	4.9360	-0.3595	13.7980	-1.7818	2.5633	-0.3594	2.2297	-1.7822
		Anguilliformes																													
			Anguillidae																												
					Anguilla																										
						Anguilla anguilla; European Eel	4.6405	-0.4031	0.7146	0.3335	<.0001	623	8.4580	-1.4810	Mostly prolonged	8.9157	-0.4026	42.9546	2.1878	2.4153	-0.4036	1.6719	-1.4780	6.8053	-0.4028	21.9209	-1.4827	3.1644	-0.4034	3.2678	-1.4792
		Gadiformes																													
			Gadidae																												
					Lota																										
						Lota lota, Burbot	3.1603	-0.3081	0.6769	0.4123	<.0001	100	5.6425	-2.2457	Burst and Prolonged	7.3614	-0.3111	83.4231	1.9962	1.3568	-0.3051	0.3620	-2.2777	5.1746	-0.3098	27.3135	-2.2274	1.9301	-0.3063	1.1449	-2.2643
		Petromyzontiformes																													
			Petromyzontidae				3.4618	-0.3591	0.9232	0.2134	<.0001	1024	5.1548	-1.7848	Burst and Prolonged	5.2650	-0.3591	16.5657	-1.7846	2.2761	-0.3591	1.6037	-1.7850	4.4270	-0.3591	10.2237	-1.7847	2.7070	-0.3591	2.5989	-1.7849
					Lampetra																										
						Lampetra tridentata; Pacific Lamprey						24																			

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Linear Regression *U.* vs *t.*						*X.* vs *V.* Equation		Comment	95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	RMSE	p	n	M	a		K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
					Petromyzon																										
						Petromyzon marinus; Sea Lamprey	3.7187	-0.3756	0.9548	0.1654	<.0001	1000	5.6665	-1.6624	Burst and Prolonged	5.1466	-0.3756	13.4583	1.6383	2.6870	-0.3756	2.3856	-1.6626	4.4995	-0.3756	9.4118	-1.6623	3.0733	-0.3756	3.4115	-1.6625
Pike Group (data)																															
		Esociformes																													
			Esocidae																												
					Esox		2.4140	-0.2751	0.4634	0.1832	<.0001	138	2.9010	-2.6348	Lacking burst	3.6290	-0.2803	11.9619	-2.5673	1.6058	-0.2699	0.6664	-2.7050	3.0632	-0.2782	6.6796	-2.5950	1.9025	-0.2721	1.2368	-2.6755
						Esox lucius; Northern Pike						128			Prolonged																
						Esox sp.; Tiger Muskellunge						10																			
Pike Group (Derived) - curve derived by assuming burst performance similar to Salmon and Walleye, and Eel groups																															
Sturgeon							0.7506	-0.1294	0.6858	0.1513	<.0001	1008	0.0056	-6.7253		1.0106	-0.1295	0.0553	-6.7235	0.5575	-0.1294	0.0006	-6.7272	0.8937	-0.1295	0.0214	-6.7243	0.6304	-0.1294	0.0014	-6.7264
		Acipenseriformes																													
			Acipenseridae				0.7506	-0.1294	0.6858	0.1513	<.0001	1008	0.0056	-6.7253		1.0106	-0.1295	0.0553	-6.7235	0.5575	-0.1294	0.0006	-6.7272	0.8937	-0.1295	0.0214	-6.7243	0.6304	-0.1294	0.0014	-6.7264
					Acipenser		0.7238	-0.1249	0.6952	0.1410	<.0001	951	0.0037	-7.0085		0.9550	-0.1249	0.0339	-7.0062	0.5485	-0.1248	0.0004	-7.0108	0.8516	-0.1249	0.0135	-7.0071	0.6151	-0.1248	0.0010	-7.0099
						Acipenser brevirostrum; Shortnose Sturgeon	0.7232	-0.1220	0.7121	0.1269	<.0001	660	0.0034	-7.1964	Burst and prolonged	0.9282	-0.1220	0.0260	-0.0745	0.5635	-0.1220	0.0004	-7.1972	0.8372	-0.1220	0.0111	-7.1959	0.6247	-0.1220	0.0010	-7.1968
						Acipenser fulvescens; Lake Sturgeon	0.9140	-0.1709	0.7902	0.1345	<.0001	277	0.0407	-4.8530	Burst and prolonged	1.1929	-0.1709	0.1932	0.1764	0.7003	-0.1708	0.0085	-4.8557	1.0682	-0.1709	0.1013	-4.8514	0.7820	-0.1708	0.0163	-4.8546
						Acipenser transmontanus; White Sturgeon						14																			
					Scaphirhynchus		1.1457	-0.1921	0.6112	0.2492	<.0001	57	0.1590	-4.2064	Prolonged	1.8823	-0.1902	2.1534	-4.2568	0.6973	-0.1939	0.0123	-4.1570	1.5281	-0.1910	0.7166	-4.2355	0.8589	-0.1931	0.0359	-4.1776
						Scaphirhynchus albus; Pallid Sturgeon	1.4390	-0.2392	0.7869	0.1927	<.0001	52	0.4591	-3.1807	Prolonged	2.1047	-0.2368	2.2955	0.7442	0.9838	-0.2416	0.0948	-3.1397	1.7937	-0.2378	1.1621	-3.2048	1.1544	-0.2406	0.1833	-3.1569
						Scaphirhynchus platorynchus; Shovelnose Sturgeon						5																			
Salmon and Walleye							3.8347	-0.2444	0.7008	0.3465	<.0001	17085	25.1338	-3.0917	Comprehensive dataset	7.5639	-0.2444	404.8986	-3.0917	1.9441	-0.2444	1.5600	-3.0918	5.7131	-0.2444	128.4412	-3.0917	2.5738	-0.2444	4.9181	-3.0918
	Walleye Group						4.1496	-0.2430	0.6730	0.3260		8470	35.6596	-3.1152																	
		Cypriniformes					3.8641	-0.2273	0.6399	0.3282	<.0001	6044	36.2197	-3.4002	Burst and Prolonged	7.3540	-0.2273	614.5622	-3.4000	2.0303	-0.2273	2.1341	-3.4004	5.6372	-0.2273	190.7990	-3.4001	2.6487	-0.2273	6.8751	-3.4003
			Catostomidae																												
				Catostominae																											
					Catostomus		4.3459	-0.2373	0.8030	0.3081	<.0001	1063	48.5386	-3.2141	Burst and Prolonged	7.9660	-0.2374	621.4647	-3.2120	2.3710	-0.2372	3.7815	-3.2161	6.2007	-0.2374	216.6467	-3.2128	3.0459	-0.2372	10.8654	-3.2153
						Catostomus catostomus; Longnose Sucker						150																			
						Catostomus commersoni; White Sucker	7.9895	-0.3776	0.9342	0.1268	<.0001	287	42.4332	-1.6482	Burst and Prolonged	10.2252	-0.3767	82.5314	2.3249	6.2426	-0.3785	21.8870	-1.6419	9.2315	-0.3771	62.6226	-1.6520	6.9146	-0.3781	28.7845	-1.6445
						Catostomus laipinnis; Flannelmouth Sucker						588																			
						Catostomus macrocheilus; Largescale Sucker						24																			
						Catostomus platyrhynchus; Mountain Sucker						14																			
					Chasmistes																										
						Chasmistes liorus; June Sucker						26																			
			Cyprinidae				3.7563	-0.2241	0.5669	0.3313	<.0001	4947	34.1619	-3.4621	Mainly prolonged	7.1932	-0.2241	620.2517	-3.4620	1.9615	-0.2241	1.8815	-3.4621	5.4998	-0.2241	187.2416	-3.4621	2.5655	-0.2241	6.2327	-3.4621
						Abramis brama; Bream	5.2215	-0.2890	0.7774	0.1844	<.0001	1123	38.0435	-2.4604	Prolonged	7.5064	-0.2891	133.2679	2.0157	3.6321	-0.2889	10.8490	-2.4618	6.4604	-0.2891	79.3785	-2.4595	4.2201	-0.2889	18.2266	-2.4612
						Barbus barbus; Barbel	6.1163	-0.2428	0.7131	0.2644	<.0001	1178	176.9168	-3.1186	Burst and Prolonged	10.2752	-0.2428	1501.0450	2.3297	3.6407	-0.2428	20.8688	-3.1178	8.2918	-0.2428	620.1061	-3.1190	4.5115	-0.2428	50.4886	-3.1181
						Campostoma anomalum; Central Stoneroller						10																			
						Carassius carassius; Crucian Carp	2.2545	-0.1798	0.9725	0.0653	<.0001	40	6.6995	-4.5630	Burst and Prolonged	2.5793	-0.1796	14.2121	0.9475	1.9706	-0.1799	3.1619	-4.5586	2.4366	-0.1797	10.3385	-4.5656	2.0860	-0.1798	4.3431	-4.5605

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Linear Regression *U.* vs *t.*						*X.* vs *V.* Equation		Comment	95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	RMSE	p	n	M	a		K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
					Cyprinella																										
						Cyprinella lutrensis; Red Shiner						16																			
						Cyprinella proserpina; Proserpine Shiner						10																			
						Cyprinella venusta; Blacktail Shiner						19																			
						Cyprinus carpio; Carp	1.8281	-0.1228	0.435	0.207	<.0001	119	6.5528	-7.1437	Prolonged	2.8109	-0.1249	192.8870	1.0335	1.1890	-0.1207	0.1984	-7.2828	2.3500	-0.1240	47.8417	-7.0646	1.4221	-0.1216	0.8630	-7.2243
					Gila																										
						Gila cypha; Humpback Chub						156																			
						Gila elegans; Bonytail Chub						59																			
						Gobio gobio; Gudgeon						16																			
					Hybognathus																										
						Hybognathus amarus; Silvery Minnow	2.3407	-0.1454	0.8297	0.1104	<.0001	90	20.0063	-5.8759	Prolonged	2.9239	-0.1456	91.8844	1.0729	1.8738	-0.1453	4.3449	-5.8817	2.6647	-0.1455	48.6511	-5.8726	2.0561	-0.1454	8.2199	-5.8793
						Hybognathus placitus; Plains Minnow						32																			
						Iotichthys phlegethontis; Least Chub						40																			
						Lepidomeda aliciae; Southern Leatherside Chub						21																			
					Leuciscus																										
						Leuciscus cephalus; European Chub	2.6182	-0.1526	0.4295	0.1696	<.0001	304	33.3747	-5.5531	Prolonged	3.6435	-0.1519	301.7308	1.2929	1.8814	-0.1533	3.7714	-5.5213	3.1773	-0.1522	120.8726	-5.5719	2.1575	-0.1530	9.2831	-5.5345
						Leuciscus leuciscus; Dace	2.8655	-0.1738	0.7426	0.1806	<.0001	362	29.9181	-4.7522	Prolonged	4.0870	-0.1737	232.1802	1.4078	2.0090	-0.1740	3.8699	-4.7469	3.5282	-0.1738	99.3382	-4.7554	2.3273	-0.1739	9.0224	-4.7491
						Luxilus chrysocephalus; Striped Shiner						10																			
					Lythrurus																										
						Lythrurus fumeus; Ribbon Shiner						11																			
						Lythrurus umbratilis; Redfin Shiner						13																			
						Macrhybopsis aestivalis; Speckled Chub						11																			
					Notropis		2.8271	-0.2250	0.5466	0.2740	<.0001	229	9.4813	-3.4445	Prolonged	4.8334	-0.2240	105.5434	-3.4643	1.6536	-0.2260	0.8701	-3.4248	3.8696	-0.2244	38.7507	-3.4561	2.0655	-0.2256	2.3369	-3.4330
						Notropis amabilis; Texas Shiner						29																			
						Notropis atherinoides; Emerald Shiner						10																			
						Notropis atrocaudalis; Blackspot Shiner						11																			
						Notropis bairdi; Red River Shiner						10																			
						Notropis buccula; Smalleye Shiner						10																			
						Notropis buchanani; Ghost Shiner						12																			
						Notropis hudsonius; Spottail Shiner						32																			
						Notropis oxyrhynchus; Sharpnose Shiner						10																			
						Notropis sabinae; Sabine Shiner						12																			
						Notropis shumardi; Silverband Shiner						10																			
						Notropis stramineus; Sand Shiner						18																			
						Notropis texanus; Weed Shiner						7																			
						Notropis topeka; Topeka Shiner	2.9038	-0.1725	0.9232	0.0593	<.0001	43	33.6121	-4.7979	Prolonged	3.2833	-0.1725	68.4057	1.1888	2.5682	-0.1724	16.5096	-4.7994	3.1174	-0.1725	50.6782	-4.7970	2.7049	-0.1725	22.2903	-4.7988
						Notropis volucellus; Mimic Shiner						15																			
					Pimephales																										
						Pimephales promelas; Fathead Minnow						75																			

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Linear Regression *U.* vs *t.*						*X.* vs *V.* Equation		Comment	95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	RMSE	p	n	M	a		K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
						Pimephales vigilax; Bullhead Minnow						12																			
						Platygobio gracilus; Flathead Chub						26																			
						Pogonichthys macrolepidotus; Sacramento Splittail						66																			
					Ptychocheilus																										
						Ptychocheilus lucius; Colorado Squawfish	1.0781	-0.1182	0.7823	0.1115	<.0001	345	0.0873	-7.4597	Prolonged	1.3432	-0.1182	0.5613	0.2951	0.8652	-0.1182	0.0136	-7.4594	1.2263	-0.1182	0.2598	-7.4599	0.9477	-0.1182	0.0294	-7.4596
						Ptychocheilus oregonensis; Northern Squawfish						106																			
					Rhinichthys																										
						Rhinichthys atratulus; Blacknose Dace						32																			
						Rhinichthys cataractae; Longnose Dace						15																			
						Rhinichthys osculus; Speckled Dace						20																			
						Richardsonius balteatus; Redside Shiner						18																			
						Rutilus rutilus; Roach	2.3123	-0.1449	0.7588	0.1511	<.0001	354	18.7318	-5.9022	Prolonged	3.1125	-0.1447	146.5666	1.1354	1.7179	-0.1450	2.4031	-5.8959	2.7521	-0.1448	62.4929	-5.9059	1.9429	-0.1450	5.6220	-5.8985
						Semotilus atromaculatus; Creek Chub						9																			
		Perciformes – some families are grouped with the Catfish and Sunfish Group due to swimming performance					6.5564	-0.3291	0.849	0.305	<.0001	1420	44.1775	-2.0382		11.9445	-0.3292	272.8891	-2.0374	3.5988	-0.3291	7.1455	-2.0389	9.3216	-0.3292	128.5797	-2.0377	4.6115	-0.3291	15.1739	-2.0386
			Moronidae				10.1893	-0.4182	0.9873	0.1042	<.0001	285	50.6688	-1.3911		12.5178	-0.4182	82.8750	-1.3911	8.2940	-0.4182	30.9778	-1.3912	11.4945	-0.4182	67.5893	-1.3911	9.0324	-0.4182	37.9840	-1.3911
					Morone		10.1893	-0.4182	0.9873	0.1042	<.0001	285	50.6688	-1.3911	Mostly burst	12.5178	-0.4182	82.8750	-1.3911	8.2940	-0.4182	30.9778	-1.3912	11.4945	-0.4182	67.5893	-1.3911	9.0324	-0.4182	37.9840	-1.3911
						Morone americana; White Perch						100																			
						Morone saxatilis; Striped Bass	14.9421	-0.5205	0.7797	0.1214	<.0001	185	47.7301	-0.9214	Burst	19.1732	-0.5225	75.7616	2.9535	11.6448	-0.5184	29.9595	-0.9291	17.2881	-0.5217	62.5676	-0.9169	12.9146	-0.5192	36.3653	-0.9259
			Percidae				7.9407	-0.3558	0.8609	0.3228	<.0001	372	54.2494	-1.8104		15.0066	-0.3559	324.3774	-1.8102	4.2018	-0.3558	9.0705	-1.8106	11.5298	-0.3558	154.6924	-1.8103	5.4689	-0.3558	19.0232	-1.8105
					Etheostoma							4																			
						Etheostoma grahami; Rio Grande Darter						4																			
					Perca		0.9472	-0.1085	0.0761	0.3687	0.0007	147	0.0256	-8.2129	Prolonged	2.0340	-0.1119	24.8482	-7.9359	0.4411	-0.1052	0.0000	-8.5076	1.4805	-0.1105	1.4998	-8.0490	0.6060	-0.1066	0.0004	-8.3828
						Perca flavescens; Yellow Perch	1.4177	-0.1673	0.4005	0.2078	<.0001	131	0.5418	-4.9764	Prolonged	2.1799	-0.1691	6.8314	0.7793	0.9221	-0.1656	0.0407	-5.0395	1.8227	-0.1683	2.3958	-4.9402	1.1027	-0.1663	0.1203	-5.0131
						Perca fluviatilis; European Perch						16																			
					Sander							221				15.1280	-0.4197	127.9366	-1.3825	8.2415	-0.4202	29.9646	-1.3796	13.3376	-0.4198	94.6538	-1.3819	9.3478	-0.4201	40.4776	-1.3802
						Sander vitreus; Walleye	11.1659	-0.4200	0.9645	0.1541	<.0001	221	61.8887	-1.3810	Burst and Prolonged	15.1280	-0.4197	127.9366	2.7165	8.2415	-0.4202	29.9646	-1.3796	13.3376	-0.4198	94.6538	-1.3819	9.3478	-0.4201	40.4776	-1.3802
		Salmoniformes										10392																			
			Salmonidae				3.5839	-0.2458	0.7441	0.3277	<.0001	10392	18.6057	-3.0675		6.8139	-0.2459	253.8435	-3.0675	1.8851	-0.2458	[illegible]	-3.0676	5.2254	-0.2459	86.2426	-3.0675	2.4581	-0.2458	4.0138	-3.0676
				Coregoninae			0.7812	-0.0738	0.0368	0.2351	0.0001	387	0.0010	-12.5519		1.2499	-0.0746	0.5670	-12.4064	0.4882	-0.0730	0.0000	-12.7006	1.0288	-0.0743	0.0416	-12.4663	0.5931	-0.0733	0.0000	-12.6387
					Coregonus		0.8679	-0.0836	0.0562	0.2204	<.0001	359	0.0059	-10.9688		1.3497	-0.0844	1.1332	-10.8501	0.5581	-0.0827	0.0000	-11.0899	1.1242	-0.0840	0.1300	-10.8990	0.6701	-0.0831	0.0003	-11.0395
						Coregonus artedii; Cisco						28																			
						Coregonus autumnalis; Arctic Cisco						4																			
						Coregonus clupeaformis; Lake Whitefish	0.9137	-0.0888	0.0735	0.2081	<.0001	304	0.0124	-10.2589	Prolonged	1.3925	-0.0901	1.3705	0.3311	0.5995	-0.0876	0.0001	-10.4219	1.1695	-0.0896	0.1982	-10.1655	0.7139	-0.0881	0.0007	-10.3538
						Coregonus nasus; Broad Whitefish						21																			
						Coregonus sardinella; Least Cisco						2																			
					Prosopium							9																			
						Prosopium williamsoni; Mountain Whitefish						9																			
					Stenodus							19				15.4678	-0.4257	125.3350	-1.3489	11.8242	-0.4679	44.8058	-1.1373	14.5891	-0.4349	98.3586	-1.2993	12.5364	-0.4587	55.0849	-1.1800
						Stenodus leucichthys; Inconnu	13.5238	-0.4468	0.2365	0.1385	0.0347	19	72.9947	-1.2381		15.4678	-0.4257	125.3350	2.7388	11.8242	-0.4679	44.8058	-1.1373	14.5891	-0.4349	98.3586	-1.2993	12.5364	-0.4587	55.0849	-1.1800
	Salmon and Trout Group																														
				Salmoninae			3.6078	-0.2482	0.7482	0.3431	<.0001	8615	18.3860	-3.0286		7.0693	-0.2482	276.2440	-3.0285	1.8413	-0.2482	1.2236	-3.0287	5.3542	-0.2482	90.1856	-3.0285	2.4311	-0.2482	3.7482	-3.0286

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Linear Regression *U*. vs *t*.						*X*. vs *V*. Equation		Comment	95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	RMSE	p	n	M	a		K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
					Oncorhynchus		3.5825	-0.2621	0.8556	0.2898	<.0001	6077	14.5003	-2.8157	Burst and Prolonged	6.3234	-0.2621	126.7429	-2.8156	2.0296	-0.2621	1.6588	-2.8158	5.0003	-0.2621	51.7535	-2.8157	2.5666	-0.2621	4.0626	-2.8157
						Oncorhynchus clarki; Cutthroat Trout						161																			
						Oncorhynchus gorbuscha; Pink Salmon	0.6702	-0.0700	0.0506	0.2995	<.0001	588	0.0001	-13.2846	Prolonged	1.2152	-0.0707	0.4252	0.1949	0.3697	-0.0694	0.0000	-13.4189	0.9500	-0.0704	0.0130	-13.2071	0.4728	-0.0696	0.0000	-13.3631
						Oncorhynchus keta; Chum Salmon	1.4394	-0.1832	0.5272	0.1470	<.0001	445	0.5426	-4.4583	Prolonged	1.9301	-0.1836	2.6747	0.6575	1.0734	-0.1828	0.1092	-4.4714	1.7094	-0.1835	1.3833	-4.4507	1.2120	-0.1830	0.2123	-4.4660
						Oncorhynchus kisutch; Coho Salmon	3.1129	-0.2335	0.6377	0.3729	<.0001	549	12.6285	-3.2830	Burst and Prolonged	6.4969	-0.2338	292.5483	1.8713	1.4915	-0.2332	0.5409	-3.2883	4.7918	-0.2337	79.7819	-3.2798	2.0222	-0.2333	1.9935	-3.2861
						Oncorhynchus mykiss; Rainbow Trout	2.9153	-0.2424	0.5535	0.2441	<.0001	1217	8.4122	-3.1259	Prolonged	4.7142	-0.2425	60.9094	-3.1233	1.8028	-0.2422	1.1589	-3.1285	3.8648	-0.2425	26.8783	-3.1244	2.1991	-0.2423	2.6306	-3.1275
						Oncorhynchus mykiss; Steelhead Trout	3.6205	-0.2664	0.9079	0.2300	<.0001	1867	14.2017	-2.7533	Burst and Prolonged	5.6844	-0.2664	77.2776	-2.7540	2.3060	-0.2665	2.6115	-2.7527	4.7176	-0.2664	38.3682	-2.7537	2.7786	-0.2665	5.2577	-2.7529
						Oncorhynchus nerka; Sockeye Salmon						36																			
						Oncorhynchus tshawytscha; Chinook Salmon	4.0056	-0.2769	0.8905	0.2781	<.0001	1214	17.8156	-2.6108	Burst and Prolonged	6.9150	-0.2770	127.9168	1.9337	2.3203	-0.2769	2.4810	-2.6109	5.5178	-0.2770	56.6274	-2.6107	2.9078	-0.2769	5.6047	-2.6108
					Salmo		2.5995	-0.1661	0.3131	0.3341	<.0001	1734	20.9805	-5.0194	Burst and Prolonged	5.0092	-0.1662	1085.5931	-5.0179	1.3490	-0.1661	0.4047	-5.0209	3.8198	-0.1662	212.5464	-5.0185	1.7691	-0.1661	2.0696	-5.0202
						Salmo salar; Atlantic Salmon	2.0491	-0.1321	0.1830	0.3405	<.0001	1065	11.9077	-6.5727	Burst and Prolonged	4.0074	-0.1323	1878.4917	1.3881	1.0477	-0.1318	0.0740	-6.5875	3.0369	-0.1322	232.3524	-6.5641	1.3826	-0.1319	0.6061	-6.5814
						Salmo trutta; Brown Trout	3.3524	-0.2063	0.4896	0.3136	<.0001	669	29.8227	-3.8463	Prolonged	6.2053	-0.2062	592.2661	1.8254	1.8111	-0.2065	1.5071	-3.8433	4.8101	-0.2063	171.9678	-3.8480	2.3364	-0.2064	5.1783	-3.8445
					Salvelinus		1.5970	-0.1141	0.2739	0.2172	<.0001	804	2.6933	-7.7621		2.4552	-0.1145	113.8581	-7.7312	1.0388	-0.1137	0.0620	-7.7932	2.0551	-0.1144	24.2836	-7.7439	1.2410	-0.1139	0.2960	-7.7803
						Salvelinus alpinus; Arctic Char	0.5768	0.0060	0.0008	0.2122	0.7302	154	-9.0041E+36	166.7235		0.9078	0.0021	-1.5535E+17	-0.0967	0.3664	0.0100	-1.4633E+41	101.0033	0.7518	0.0037	-2.9222E+30	270.0805	0.4424	0.0084	-7.7439E+39	120.7328
						Salvelinus confluentus; Bull Trout	68.9599	-0.5447	0.8929	0.0780	<.0001	106	670.1783	-0.8360	Prolonged	78.0677	-0.5409	880.9450	4.3576	60.9147	-0.5484	511.8089	-0.8234	74.1353	-0.5425	785.7105	-0.8435	64.1459	-0.5469	572.3854	-0.8286
						Salvelinus fontinalis; Brook Trout	1.9198	-0.1442	0.4801	0.2050	<.0001	454	5.2662	-5.9324	Mostly prolonged	2.8839	-0.1447	86.7648	1.0591	1.2781	-0.1438	0.3142	-5.9535	2.4369	-0.1445	27.2640	-5.9201	1.5125	-0.1440	1.0112	-5.9448
						Salvelinus namaycush; Lake Trout	5.6171	-0.2462	0.6832	0.0267	<.0001	90	114.8038	-3.0620		5.9471	-0.2466	143.2486	1.7829	5.3054	-0.2458	91.9369	-3.0690	5.8071	-0.2464	130.6212	-3.0579	5.4333	-0.2459	100.8755	-3.0661
	Walleye Group (con't) – Grayling swimming performance fit best with Walleye Group																														
				Thymallinae								1390																			
					Thymallus		3.1729	-0.2167	0.7675	0.2041	<.0001	1390	18.4587	-3.6139		4.7372	-0.2168	117.2093	-3.6133	2.1252	-0.2167	2.9056	-3.6145	4.0140	-0.2168	54.5975	-3.6135	2.5081	-0.2167	6.2396	-3.6142
						Thymallus arcticus; Arctic Grayling	0.0029	0.6103	0.8839	0.0431	<.0001	89	-2488.0112	2.6386		0.0031	0.6147	-2153.1120	-5.7903	0.0028	0.6059	-2881.1522	2.6505	0.0030	0.6128	-2286.4338	2.6317	0.0028	0.6077	-2709.3251	2.6455
						Thymallus thymallus; European Grayling	3.1425	-0.2142	0.7704	0.2038	<.0001	1301	18.5396	-3.6680	Prolonged	4.6893	-0.2142	120.0229	1.5453	2.1059	-0.2142	2.8625	-3.6685	3.9742	-0.2142	55.4604	-3.6677	2.4848	-0.2142	6.1966	-3.6683
	Trout Freshwater Group – brook, brown, bull, lake, rainbow trouts						4.5626	-0.2728	0.6005	0.3297	<.0001	2536	30.4471	-2.6657		8.7168	-0.2729	325.9635	-2.6645	2.3882	-0.2727	2.8396	-2.6669	6.6709	-0.2729	122.4018	-2.6650	3.1207	-0.2727	7.5696	-2.6664
	Rainbow Trout and Steelhead						3.5961	-0.2659	0.9110	0.2363	<.0001	3084	13.9378	-2.7602		5.7153	-0.2659	79.5873	-2.7603	2.2627	-0.2660	2.4411	-2.7601	4.7196	-0.2659	38.7431	-2.7602	2.7400	-0.2659	5.0142	-2.7601
	Walleye and White Sucker						8.8094	-0.3889	0.9478	0.1562	<.0001	508	48.2764	-1.5716		11.9663	-0.3886	106.4809	-1.5733	6.4853	-0.3891	21.9105	-1.5699	10.5418	-0.3887	76.7465	-1.5726	7.3616	-0.3890	30.3786	-1.5706

Table A2b. Summary of least squares regressions for fatigue curves in body lengths per second (U/l versus t) with 95% and 75% prediction intervals for selected groups and taxonomic levels. Missing results correspond to limited data which prevented meaningful regressions. Taxonomic classification is from the Integrated Taxonomic Information System - ITIS.

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Linear Regression *U/l* vs *t*						*X*· vs *V*· Equation		95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	RMSE	p	n	M	a	K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
Catfish and Sunfish Group							11.111	-0.202	0.561	0.266	<0.0001	1282	12247.2624	-3.9429	18.7612	-0.2025	161497.8506	-3.9392	6.5805	-0.2022	925.1563	-3.9466	15.1085	-0.2024	55635.3088	-3.9407	8.1714	-0.2022	2692.4263	-3.9451
		Perciformes– some families are grouped with the Walleye and Salmon Group due to swimming performance					18.344	-0.275	0.755	0.319	<0.0001	1420	4642.1878	-2.6373	34.3183	-0.2750	45139.28319	-2.6361	9.8054	-0.2748	476.7147	-2.6385	26.4903	-0.2750	17632.9036	-2.6366	12.7030	-0.2749	1221.5296	-2.6380
			Centrarchidae				14.414	-0.230	0.433	0.284	<0.0001	755	10642.4727	-3.3547	25.3451	-0.2306	117668.7676	-3.3362	8.1972	-0.2287	943.0396	-3.3732	20.0689	-0.2302	43664.2420	-3.3438	10.3523	-0.2291	2575.7312	-3.3655
					Lepomis		8.561	-0.027	0.047	0.190	0.2163	34	1.0967E+32	-35.4932	12.5261	-0.0223	1.7364E+47	-43.9270	5.8509	-0.0325	4.5553E+21	-29.7253	10.6561	-0.0244	9.9703E+39	-39.9105	6.8777	-0.0304	4.3387E+25	-31.9368
						Lepomis auritus; Redbreast Sunfish						5																		
						Lepomis incisor; Sunfish	12.785	-0.100	0.867	0.066	<0.0001	20	4.0944E+09	-8.9595	14.6826601	-0.098830022	24489296513	-9.1183828	11.13253	-0.101984	7.2367E+08	-8.8055	13.8263	-0.0995	1.1186E+10	-9.0488	11.8220	-0.1013	1.5256E+09	-8.8718
						Lepomis macrochirus; Bluegill						4																		
						Lepomis megalotis; Longear Sunfish						5																		
					Micropterus		13.088	-0.216	0.252	0.279	<0.0001	702	13342.4837	-3.6333	22.9129	-0.2173	162952.8070	-3.6013	7.4754	-0.2143	1054.9333	-3.6658	18.1753	-0.2167	58125.6038	-3.6145	9.4239	-0.2149	3026.1052	-3.6523
						Micropterus dolomieu; Smallmouth Bass	6.689	-0.125	0.426	0.123	<0.0001	117	195485.5933	-6.9967	8.5219	-0.1245	1453399.3456	-7.0311	5.2498	-0.1256	26748.2197	-6.9625	7.7045	-0.1247	629158.7794	-7.0167	5.8068	-0.1254	61095.2614	-6.9767
						Micropterus salmoides; Largemouth Bass	16.454	-0.247	0.267	0.296	<0.0001	585	8693.9724	-3.0468	29.9961	-0.2495	87369.2370	-3.0074	9.0251	-0.2447	826.5079	-3.0869	23.3973	-0.2485	33816.6242	-3.0236	11.5705	-0.2457	2200.3415	-3.0702
					Pomoxis																									
						Pomoxis annularis; White Crappie						20																		
		Siluriformes																												
			Ictaluridae																											
					Ictalurus		12.827	-0.251	0.840	0.171	<0.0001	527	2727.4325	-2.9798	17.9778	-0.2514	10395.8347	-2.9777	9.1514	-0.2511	714.5285	-2.9820	15.6339	-0.2513	5977.0292	-2.9786	10.5235	-0.2512	1243.9601	-2.9811
						Ictalurus furcatus; Blue Catfish	20.683	-0.368	0.905	0.152	<0.0001	183	632.1875	-1.7194	28.0825	-0.3686	1425.3856	-1.7129	15.2325	-0.3668	279.2951	-1.7259	24.7340	-0.3682	1017.5669	-1.7156	17.2947	-0.3672	392.2371	-1.7232
						Ictalurus punctatus; Channel Catfish	13.188	-0.237	0.978	0.029	<0.0001	70	5371.3971	-3.2265	13.9675	-0.2364	6900.0141	-3.2297	12.4513	-0.2368	4183.0204	-3.2233	13.6356	-0.2365	6213.0799	-3.2284	12.7543	-0.2367	4644.3346	-3.2246
						Ictalurus punctatus x furcatus; Channel x blue hybrid	10.962	-0.212	0.961	0.076	<0.0001	274	7055.9945	-3.7187	12.7531	-0.2120	14329.9437	-3.7163	9.4230	-0.2118	3471.8448	-3.7211	11.9780	-0.2120	10684.7803	-3.7173	10.0329	-0.2119	4658.4774	-3.7201
Clupeidae (Herring) Group							29.3896	-0.4164	0.830	0.179	<0.0001	592	656.9024	-1.4014	41.7270	-0.4160	1536.7380	-1.4040	20.7000	-0.4169	281.3110	-1.3989	36.0946	-0.4162	1080.9537	-1.4029	23.9301	-0.4167	399.4518	-1.3999
		Clupeiformes																												
			Clupeidae																											
				Alosinae																										
					Alosa		29.3896	-0.4164	0.8297	0.1787	<0.0001	592	656.9024	-1.4014	41.7270	-0.4160	1536.7380	-1.4040	20.7000	-0.4169	281.3110	-1.3989	36.0946	-0.4162	1080.9537	-1.4029	23.9301	-0.4167	399.4518	-1.3999
						Alosa aestivalis; Blueback Herring	33.3210	-0.3672	0.9631	0.0613	<0.0001	75	2342.7189	-1.7237	37.6413	-0.3663	3328.7181	-1.7297	29.4966	-0.3680	1651.3638	-1.7176	35.7704	-0.3667	2873.4173	-1.7272	31.0394	-0.3676	1911.0483	-1.7201
						Alosa fallax; Twaite Shad						19																		
						Alosa pseudoharengus; Alewife	33.1389	-0.4137	0.8919	0.0979	<0.0001	204	917.8756	-1.4170	40.3297	-0.4146	1451.0955	-1.4117	27.2302	-0.4128	579.4358	-1.4223	37.1739	-0.4143	1200.2455	-1.4139	29.5419	-0.4132	701.4569	-1.4201
						Alosa sapidissima; American Shad	24.7753	-0.3997	0.9833	0.0501	<0.0001	294	571.3104	-1.5022	27.3469	-0.3996	732.1330	-1.5025	22.4455	-0.3997	445.8438	-1.5018	26.2505	-0.3996	660.6239	-1.5024	23.3830	-0.3997	494.0828	-1.5020
Eel Group							10.6867	-0.3560	0.779	0.342	<0.0001	1747	124.6628	-1.8090	20.9233	-0.3561	8.2209E+02	-1.8086	5.4564	-0.3560	1.8871E+01	-1.8092	15.8492	-0.3560	3.7693E+02	-1.8087	7.2033	-0.3560	4.1168E+01	-1.8090
		Anguilliformes																												
			Anguillidae																											
					Anguilla																									
						Anguilla anguilla; European Eel	15.7210	-0.4250	0.67	0.391	<0.0001	623	131.3662	-1.3529	33.8262	-0.4239	811.0031	-1.3588	7.3062	-0.4253	21.5915	-1.3511	24.6372	-0.4242	382.3500	-1.3572	10.0312	-0.4250	45.6193	-1.3527
		Gadiformes																												
			Gadidae																											
					Lota																									
						Lota lota; Burbot	14.4689	-0.3640	0.67	0.523	<0.0001	100	254.5066	-1.7473	41.9389	-0.3678	4.3194E+03	-1.7192	4.9937	-0.3605	1.4123E+01	-1.7741	26.9143	-0.3662	1.3351E+03	-1.7304	7.7813	-0.3620	4.7449E+01	-1.7625
		Petromyzontiformes																												
			Petromyzontidae				9.3287	-0.3446	0.8989	0.2323	<0.0001	1024	100.6892	-1.9023	14.7230	-0.3446	378.4025	-1.9021	5.9108	-0.3445	26.7874	-1.9025	12.1917	-0.3446	218.9015	-1.9022	7.1380	-0.3445	46.3115	-1.9024

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Linear Regression *U/l vs t*						*X· vs V·* Equation		95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	RMSE	p	n	M	a	K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
					Lampetra																									
						Lampetra tridentata; Pacific Lamprey						24																		
					Petromyzon																									
						Petromyzon marinus, Sea Lamprey	9.7085	-0.3590	0.917	0.211	<0.0001	1000	91.1930	-1.7855	14.7087	-0.3587	2.9184E+02	-1.7882	6.4135	-0.3586	2.8856E+01	-1.7885	12.3895	-0.3586	1.8090E+02	-1.7883	7.6140	-0.3586	4.6558E+01	-1.7884
Pike Group (data)							69.5923	-0.5571	0.383	0.411	<0.0001	138	591.9878	-0.7951	162.5495	-0.5624	2525.3696	-0.7782	29.7945	-0.5518	134.9887	-0.8123	114.2335	-0.5602	1386.1159	-0.7852	42.3964	-0.5540	250.4550	-0.8051
		Esociformes																												
			Esocidae																											
					Esox		69.5923	-0.5571	0.3829	0.4107	<0.0001	138	591.9878	-0.7951	162.5495	-0.5624	2525.3696	-0.7782	29.7945	-0.5518	134.9887	-0.8123	114.2335	-0.5602	1386.1159	-0.7852	42.3964	-0.5540	250.4550	-0.8051
						Esox lucius; Northern Pike						128																		
						Esox sp.; Tiger Muskellunge						10																		
Pike Group (Derived)- curve derived by assuming burst performance similar to Salmon and Walleye and Eel groups																														
Sturgeon							4.2858	-0.1366	0.3926	0.2918	<0.0001	1008	2284.8954	-6.3201	7.6042	-0.1367	151311.5012	-6.3179	2.4156	-0.1366	34.4155	-6.3223	5.9993	-0.1366	26737.6202	-6.3188	3.0618	-0.1366	195.0873	-6.3214
		Acipenseriformes																												
			Acipenseridae				4.2858	-0.1366	0.3926	0.2918	<0.0001	1008	2284.8954	-6.3201	7.6042	-0.1367	151311.5012	-6.3179	2.4156	-0.1366	34.4155	-6.3223	5.9993	-0.1366	26737.6202	-6.3188	3.0618	-0.1366	195.0873	-6.3214
					Acipenser		4.1112	-0.1296	0.3556	0.2945	<0.0001	951	2796.9913	-6.7187	7.3339	-0.1296	242200.6686	-6.7154	2.3047	-0.1295	32.1760	-6.7221	5.7730	-0.1296	38308.4681	-6.7168	2.9278	-0.1295	203.9441	-6.7207
						Acipenser brevirostrum; Shortnose Sturgeon	5.3065	-0.1541	0.6304	0.1992	<0.0001	660	3105.4232	-5.4889	7.8512	-0.1541	39411.9933	-5.4884	3.5866	-0.1541	244.5876	-5.4895	6.6768	-0.1541	13778.3474	-5.4886	4.2175	-0.1541	699.8146	-5.4892
						Acipenser fulvescens; Lake Sturgeon	3.8429	-0.1739	0.4393	0.2948	<0.0001	277	161.5862	-4.7508	6.8855	-0.1740	4581.2927	-4.7456	2.1448	-0.1737	5.6649	-4.7560	5.4072	-0.1740	1146.3649	-4.7477	2.7312	-0.1738	22.7292	-4.7538
						Acipenser transmontanus; White Sturgeon						14																		
					Scaphirhynchus		6.5301	-0.2264	0.8277	0.1770	<0.0001	57	374.2020	-3.4165	9.3166	-0.2251	1892.7080	-3.4426	4.5770	-0.2277	75.3959	-3.3908	8.0252	-0.2257	956.0974	-3.4316	5.3135	-0.2272	147.3928	-3.4016
						Scaphirhynchus albus; Pallid Sturgeon	6.7274	-0.2363	0.8080	0.1781	<0.0001	52	314.9546	-3.2316	9.6037	-0.2342	1534.7921	-3.2705	4.7126	-0.2385	66.5111	-3.1935	8.2685	-0.2351	785.7059	-3.2540	5.4736	-0.2376	127.4721	-3.2094
						Scaphirhynchus platorynchus; Shovelnose Sturgeon						5																		
Salmon and Walleye							12.3242	-0.1485	0.3104	0.4218	<0.0001	17085	1.3025E+06	-5.7322	28.1752	-0.1485	3.4049E+08	-5.7320	5.3908	-0.1485	4980.7878	-5.7324	20.0226	-0.1485	3.4160E+07	-5.7321	7.5858	-0.1485	49655.0695	-5.7323
	Walleye Group						19.3753	-0.1260	0.4400	0.4430	<0.0001	8470	8.1456E+08	-6.9365																
		Cypriniformes					19.9908	-0.1992	0.4446	0.4080	<0.0001	6044	2.7694E+05	-4.0206	44.4912	-0.1992	1.5357E+07	-4.0203	8.9823	-0.1992	4991.7366	-4.0209	31.9693	-0.1992	2.9231E+06	-4.0204	12.5006	-0.1992	26232.5637	-4.0208
			Catostomidae																											
				Catostominae			11.5675	-0.1189	0.2254	0.4855	<0.0001	1089	4.0793E+07	-7.4109	30.0529	-0.1191	1.1883E+11	-7.3946	4.4524	-0.1187	13575.0983	-7.4273	20.2518	-0.1190	4.4090E+09	-7.4013	6.6071	-0.1188	3.7341E+05	-7.4205
					Catostomus		11.6169	-0.1191	0.2318	0.4833	<0.0001	1063	4.1127E+07	-7.3990	30.0544	-0.1193	1.1439E+11	-7.3828	4.4903	-0.1188	14340.7063	-7.4152	20.2880	-0.1192	4.3257E+09	-7.3895	6.6519	-0.1189	3.8693E+05	-7.4085
						Catostomus catostomus; Longnose Sucker						150																		
						Catostomus commersoni; White Sucker	20.1172	-0.3418	0.8830	0.1482	<0.0001	287	995.6950	-1.9260	26.8802	-0.3407	2389.1508	-1.9355	15.0557	-0.3429	417.3158	-1.9165	23.8384	-0.3411	1661.2421	-1.9315	16.9768	-0.3424	597.9459	-1.9204
						Catostomus laipinnis; Flannelmouth Sucker						588																		
						Catostomus macrocheilus; Largescale Sucker						24																		
						Catostomus platyrhynchus; Mountain Sucker						14																		
					Chasmistes																									
						Chasmistes liorus; June Sucker						26																		
			Cyprinidae				22.8236	-0.2234	0.4968	0.3764	<0.0001	4947	111789.0727	-3.4767	47.7473	-0.2234	3042827.7613	-3.4766	10.9098	-0.2234	4106.2065	-3.4768	35.1971	-0.2234	7.7708E+05	-3.4766	14.7999	-0.2234	16080.7059	-3.4768
						Abramis brama; Bream	28.1366	-0.2855	0.7641	0.1881	<0.0001	1123	14675.7341	-2.5027	40.7320	-0.2856	53353.3436	-2.5012	19.4360	-0.2854	4032.3335	-2.5042	34.9556	-0.2856	31295.3899	-2.5018	22.6478	-0.2854	6879.4482	-2.5036
						Barbus barbus;	32.9326	-0.2440	0.5930	0.3426	<0.0001	1178	170440.9184	-3.0989	64.5069	-0.2439	2692179.9905	-3.0999	16.8131	-0.2440	10805.4192	-3.0979	48.8545	-0.2439	8.6014E+05	-3.0995	22.1998	-0.2440	33789.6013	-3.0983

Group	SubGroup	Order	Family	Subfamily	Genus		Linear Regression *U/l* vs *t*						*X*· vs *V*· Equation		95% UPI				95% LPI				75% UPI				75% LPI			
						Species	K	b	R^2	RMSE	p	n	M	a	K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
						Barbel																								
						Campostoma anomalum; Central Stoneroller						10																		
						Carassius carassius; Crucian Carp	14.7267	-0.1798	0.9725	0.0653	<0.0001	40	229187.1573	-4.5630	16.8539	-0.1796	491108.9184	-4.5674	12.8680	-0.1799	1.0708E+05	-4.5586	15.9191	-0.1797	3.5574E+05	-4.5656	13.6236	-0.1798	147715.8168	-4.5605
					Cyprinella		18.6496	-0.1044	0.7185	0.1020	<0.0001	63	6.0390E+10	-8.5801	22.8697	-0.1034	5.6085E+11	-8.6710	15.2082	-0.1054	6.7785E+09	-8.4909	20.9954	-0.1038	2.1923E+11	-8.6327	16.5659	-0.1050	1.6870E+10	-8.5281
						Cyprinella lutrensis; Red Shiner						16																		
						Cyprinella proserpina; Proserpine Shiner						10																		
						Cyprinella venusta; Blacktail Shiner						19																		
						Cyprinus carpio; Carp	12.7652	-0.1336	0.1581	0.4395	<0.0001	119	1.0076E+07	-6.4876	31.6815	-0.1384	3.8133E+09	-6.2247	5.1434	-0.1287	17028.8873	-6.7704	21.7010	-0.1364	3.3919E+08	-6.3319	7.5088	-0.1307	2.5705E+05	-6.6502
					Gila							216																		
						Gila cypha; Humpback Chub						156																		
						Gila elegans; Bonytail Chub						59																		
						Gobio gobio; Gudgeon						16																		
					Hybognathus		17.0335	-0.1239	0.8005	0.1080	<0.0001	122	4.2491E+08	-7.0740	21.1054	-0.1236	2.5113E+09	-7.0898	13.7472	-0.1241	7.2396E+07	-7.0583	19.3043	-0.1237	1.1979E+09	-7.0832	15.0299	-0.1240	1.5108E+08	-7.0649
						Hybognathus amarus; Silvery Minnow	19.1303	-0.1440	0.8233	0.1115	<0.0001	90	4.5622E+07	-5.9456	23.9451	-0.1441	2.1303E+08	-5.9396	15.2837	-0.1439	9.7443E+06	-5.9516	21.8038	-0.1440	1.1202E+08	-5.9421	16.7847	-0.1439	1.8564E+07	-5.9491
						Hybognathus placitus; Plains Minnow						32																		
						Iotichthys phlegethontis; Least Chub						40																		
						Lepidomeda aliciae; Southern leatherside Chub						21																		
					Leuciscus		21.1816	-0.2142	0.4775	0.3466	<0.0001	666	1.3714E+05	-3.6686	41.8144	-0.2138	3.3777E+06	-3.6769	10.7298	-0.2146	5631.1418	-3.6604	31.5611	-0.2140	8.96E+05	-3.6735	14.2156	-0.2144	21063.6524	-3.6638
						Leuciscus cephalus; European Chub	17.7752	-0.1523	0.1149	0.3724	<0.0001	304	9.7527E+06	-5.5656	36.7986	-0.1502	1.5981E+09	-5.6590	8.5861	-0.1544	68552.5410	-5.4748	27.2211	-0.1511	1.90E+08	-5.6200	11.6071	-0.1536	525745.0254	-5.5121
						Leuciscus leuciscus; Dace	20.7204	-0.2168	0.6109	0.3168	<0.0001	362	1.0608E+05	-3.6134	38.6470	-0.2165	1.9211E+06	-3.6195	11.1092	-0.2170	5902.4918	-3.6073	29.8546	-0.2166	5.78E+05	-3.6169	14.3809	-0.2169	19506.2968	-3.6098
						Luxilus chrysocephalus; Striped Shiner						10																		
					Lythrurus							25																		
						Lythrurus fumeus; Ribbon Shiner						11																		
						Lythrurus umbratilis; Redfin Shiner						13																		
						Macrhybopsis aestivalis; Speckled Chub						11																		
					Notropis		24.9527	-0.2445	0.5663	0.2921	<0.0001	229	53230.7180	-3.0899	44.3295	-0.2435	593302.4374	-3.1072	14.0456	-0.2455	4873.4281	-3.0728	34.9295	-0.2439	217749.1394	-3.1000	17.8255	-0.2451	13103.2183	-3.0799
						Notropis amabilis; Texas Shiner						29																		
						Notropis atherinoides; Emerald Shiner						10																		
						Notropis atrocaudalis; Blackspot Shiner						11																		
						Notropis bairdi; Red River Shiner						10																		
						Notropis buccula; Smalleye Shiner						10																		
						Notropis buchanani; Ghost Shiner						12																		
						Notropis hudsonius; Spottail Shiner						32																		

Group	SubGroup	Order	Family	Subfamily	Genus		Linear Regression *U/l vs t*						*X·* vs *V·* Equation		95% UPI				95% LPI				75% UPI				75% LPI			
						Species	K	b	R^2	RMSE	p	n	M	a	K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
						Notropis oxyrhynchus; Sharpnose Shiner						10																		
						Notropis sabinae; Sabine Shiner						12																		
						Notropis shumardi; Silverband Shiner						10																		
						Notropis stramineus; Sand Shiner						18																		
						Notropis texanus; Weed Shiner						7																		
						Notropis topeka; Topeka Shiner	29.4794	-0.1813	0.8323	0.0978	<0.0001	43	9366899.63	-4.5158	36.0989	-0.1814	2.8206E+07	-4.5113	24.0737	-0.1812	3.11E+06	-4.5202	33.1399	-0.1814	1.7713E+07	-4.5132	26.2233	-0.1812	4.95E+06	-4.5183
						Notropis volucellus; Mimic Shiner						15																		
					Pimephales		7.2224	-0.0065	0.0173	0.0824	0.225	87	6.983E+128	-152.097	8.5646	-0.0074	8.7779E+123	-134.6360	6.0906	-0.0057	1.59E+135	-174.7187	7.9764	-0.0070	7.0095E+125	-141.4167	6.5397	-0.0060	2.14E+132	-164.5097
						Pimephales promelas; Fathead Minnow						75																		
						Pimephales vigilax; Bullhead Minnow						12																		
						Platygobio gracilus; Flathead Chub						26																		
						Pogonichthys macrolepidotus; Sacramento Splittail						66																		
					Ptychocheilus		3.0429	0.0471	0.0204	0.4154	0.0024	451	-9.3335E-13	22.2270	6.9043	0.0469	-2.1967E-20	22.3144	1.3411	0.0473	0.0000	22.1404	4.9186	0.0470	0.0000	22.2781	1.8825	0.0472	0.0000	22.1762
						Ptychocheilus lucius; Colorado Squawfish	1.8837	0.1570	0.4411	0.2386	<0.0001	345	-0.0009	7.3688	3.0140	0.1571	-4.7869E-05	7.3644	1.1773	0.1569	-0.0189	7.3732	2.4809	0.1571	-0.0002	7.3662	1.4303	0.1570	-0.0055	7.3713
						Ptychocheilus oregonensis; Northern Squawfish	8.5907	-0.1816	0.0382	0.1679	0.0445	106	10257.1724	-4.5076	12.1868	-0.1835	6.1600E+04	-4.4496	6.0558	-0.1796	1643.6539	-4.5667	10.5346	-0.1827	29321.7575	-4.4736	7.0056	-0.1804	3541.5618	-4.5419
					Rhinichthys							67																		
						Rhinichthys atratulus; Blacknose Dace						32																		
						Rhinichthys cataractae; Longnose Dace						15																		
						Rhinichthys osculus; Speckled Dace						20																		
						Richardsonius balteatus; Redside Shiner						18																		
						Rutilus rutilus; Roach	15.3260	-0.1496	0.5298	0.2599	<0.0001	354	4.9883E+06	-5.6837	25.5616	-0.1494	1.5675E+08	-5.6930	9.1891	-0.1498	1.6027E+05	-5.6744	20.6817	-0.1495	3.7554E+07	-5.6891	11.3573	-0.1497	6.6478E+05	-5.6782
						Semotilus atromaculatus; Creek Chub						9																		
		Perciformes – some families are grouped with the Sunfish and Catfish Group due to swimming performance					18.3441	-0.2749	0.7546	0.3188	<0.0001	1420	4642.1878	-2.6373	34.3183	-0.2750	45139.2832	-2.6361	9.8054	-0.2748	476.7147	-2.6385	26.4903	-0.2750	17632.9036	-2.6366	12.7030	-0.2749	1221.5296	-2.6380
			Moronidae																											
					Morone		22.4763	-0.3787	0.9805	0.1100	<0.0001	285	643.4008	-1.6405	27.9310	-0.3787	1141.4480	-1.6404	18.0868	-0.3787	362.6416	-1.6407	25.5261	-0.3787	900.0954	-1.6405	19.7908	-0.3787	459.9012	-1.6406
						Morone americana; White Perch																								
						Morone saxatilis; Striped Bass	30.8353	-0.5205	0.7797	0.1214	<0.0001	185	192.0099	-0.9214	39.4420	-0.5225	301.2601	-0.9137	24.1067	-0.5184	121.9394	-0.9291	35.6107	-0.5217	249.9935	-0.9169	26.7003	-0.5192	147.2938	-0.9259
			Percidae				22.4574	-0.3124	0.7610	0.3675	<0.0001	372	2896.1233	-2.2005	46.3578	-0.3125	29411.8353	-2.2001	10.8792	-0.3124	284.9830	-2.2010	34.3390	-0.3125	11264.3184	-2.2002	14.6870	-0.3124	744.4381	-2.2008
					Etheostoma							4																		
						Etheostoma grahami; Rio Grande Darter						4																		
					Perca		9.5894	-0.1535	0.1819	0.3388	<0.0001	147	152245.6171	-5.5141	19.2244	-0.1566	9823815.3129	-5.3837	4.7833	-0.1504	1983.9063	-5.6500	14.3981	-0.1553	1773959.7620	-5.4373	6.3867	-0.1517	12315.2483	-5.5929
						Perca flavescens; Yellow Perch	12.6985	-0.2126	0.5906	0.1909	<0.0001	131	13658.4539	-3.7043	18.7881	-0.2142	78255.8872	-3.6682	8.5827	-0.2109	2320.0885	-3.7409	15.9631	-0.2135	37983.1322	-3.6831	10.1016	-0.2116	4866.2415	-3.7256

Group	SubGroup	Order	Family	Subfamily	Genus		Linear Regression *U/l vs t*						*X· vs V·* Equation		95% UPI				95% LPI				75% UPI				75% LPI			
						Species	K	b	R^2	RMSE	p	n	M	a	K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
						Perca fluviatilis, European Perch						16																		
					Sander																									
						Sander vitreus; Walleye	31.0519	-0.4293	0.9334	0.2205	<0.0001	221	608.4654	-1.3291	47.9930	-0.4290	1686.9205	-1.3308	20.0909	-0.4297	219.7984	-1.3274	40.0636	-0.4292	1104.9244	-1.3301	24.0673	-0.4295	335.2439	-1.3281
		Salmoniformes																												
			Salmonidae				9.0658	-0.1111	0.2719	0.3498	<0.0001	10392	1.7967E+07	-8.0014	17.9971	-0.1111	8.6025E+09	-8.0010	4.5668	-0.1111	37505.5120	-8.0017	13.5575	-0.1111	672114666.7597	-8.0012	6.0622	-0.1111	480189.4937	-8.0016
				Coregoninae			10.4604	-0.1968	0.0851	0.3900	<0.0001	387	12171.7238	-4.0804	22.6710	-0.1976	583908.3210	-4.0600	4.8264	-0.1960	245.9235	-4.1009	16.4583	-0.1973	118028.0952	-4.0684	6.6483	-0.1964	1241.8329	-4.0924
					Coregonus		10.7195	-0.1948	0.0959	0.3754	<0.0001	359	13438.9793	-4.1331	22.5803	-0.1956	667345.0308	-4.1131	5.0888	-0.1941	346.8112	-4.1531	16.5859	-0.1953	140771.7103	-4.1214	6.9280	-0.1944	1676.2170	-4.1448
						Coregonus artedii; Cisco						28																		
						Coregonus autumnalis; Arctic Cisco						4																		
						Coregonus clupeaformis; Lake Whitefish	10.9633	-0.1990	0.1139	0.3624	<0.0001	304	13680.4806	-4.0244	22.5827	-0.2001	476541.5288	-3.9967	5.3224	-0.1979	377.5073	-4.0524	16.7399	-0.1997	109979.8688	-4.0081	7.1801	-0.1984	1678.7937	-4.0408
						Coregonus nasus; Broad Whitefish						21																		
						Coregonus sardinella; Least Cisco						2																		
					Prosopium																									
						Prosopium williamsoni; Mountain Whitefish						9																		
					Stenodus																									
						Stenodus leucichthys; Inconnu						19																		
	Salmon and Trout Group																													
				Salmoninae			8.5180	-0.0962	0.2485	0.3319	<0.0001	8615	1.75E+08	-9.3974	16.3273	-0.0962	1.5173E+11	-9.3970	4.4438	-0.0962	2.0213E+05	-9.3978	12.4789	-0.0962	9.2792E+09	-9.3972	5.8143	-0.0962	3.3062E+06	-9.3976
					Oncorhynchus		7.7442	-0.0911	0.3302	0.2837	<0.0001	6077	2.00E+08	-9.9732	13.5072	-0.0911	8.9401E+10	-9.9729	4.4401	-0.0911	4.4664E+05	-9.9736	10.7338	-0.0911	7.1829E+09	-9.9730	5.5873	-0.0911	5.5605E+06	-9.9734
						Oncorhynchus clarki; Cutthroat Trout	2.5720	0.1402	0.1490	0.1841	<0.0001	161	-5.71E-05	8.1333	3.7342	0.1391	-3.6794E-06	8.1903	1.7715	0.1413	-8.4891E-04	8.0772	3.1984	0.1395	-1.1555E-05	8.1665	2.0683	0.1408	-2.7808E-04	8.1004
						Oncorhynchus gorbuscha; Pink Salmon	19.5350	-0.2515	0.6519	0.2304	<0.0001	588	1.44E+04	-2.9761	30.8087	-0.2519	86503.8240	-2.9701	12.3866	-0.2511	2.3855E+03	-2.9821	25.5163	-0.2517	4.1231E+04	-2.9726	14.9557	-0.2513	5.0227E+03	-2.9796
						Oncorhynchus keta; Chum Salmon	13.2329	-0.1769	0.5192	0.1433	<0.0001	445	1.57E+05	-4.6531	17.5931	-0.1773	7.5539E+05	-4.6391	9.9533	-0.1765	3.2264E+04	-4.6671	15.6368	-0.1772	3.9433E+05	-4.6449	11.1986	-0.1766	6.2123E+04	-4.6613
						Oncorhynchus kisutch; Coho Salmon	5.7164	-0.0289	0.0236	0.3139	0.0003	549	1.54E+24	-33.5425	10.6157	-0.0292	1.3714E+33	-33.2115	3.0782	-0.0287	1.1516E+15	-33.8799	8.2172	-0.0291	2.8493E+29	-33.3477	3.9767	-0.0288	7.2188E+18	-33.7395
						Oncorhynchus mykiss; Rainbow Trout	11.6448	-0.1635	0.2155	0.3088	<0.0001	1217	2.18E+05	-5.1174	21.3757	-0.1636	8.8130E+06	-5.1116	6.3437	-0.1633	5.3609E+03	-5.1232	16.6293	-0.1636	1.9118E+06	-5.1140	8.1543	-0.1634	2.4828E+04	-5.1208
						Oncorhynchus mykiss; Steelhead Trout	6.7475	-0.0463	0.1526	0.2275	<0.0001	1867	1.42E+16	-20.6014	10.5413	-0.0462	2.3061E+20	-20.6268	4.3191	-0.0463	8.9381E+11	-20.5761	8.7664	-0.0463	4.1830E+18	-20.6163	5.1936	-0.0463	4.8547E+13	-20.5865
						Oncorhynchus nerka; Sockeye Salmon	6.3624	-0.0619	0.0703	0.0943	0.118	36	2.29E+11	-15.1627	7.3721	-0.0532	4.1150E+14	-17.8004	5.4910	-0.0706	8.1976E+08	-13.1740	6.9256	-0.0569	1.2922E+13	-16.5834	5.8449	-0.0669	7.4557E+09	-13.9544
						Oncorhynchus tshawytscha; Chinook Salmon	8.6592	-0.1166	0.5131	0.2663	<0.0001	1214	5.00E+06	-7.5763	14.6074	-0.1166	4.4385E+08	-7.5770	5.1331	-0.1166	5.6341E+04	-7.5757	11.7678	-0.1166	6.9470E+07	-7.5767	6.3717	-0.1166	3.5982E+05	-7.5760
					Salmo		15.1486	-0.1699	0.2379	0.4059	<0.0001	1734	6.09E+05	-4.8874	33.6026	-0.1699	6.6028E+07	-4.8863	6.8292	-0.1698	5.5983E+03	-4.8885	24.1754	-0.1699	9.5190E+06	-4.8868	9.4922	-0.1698	3.8877E+04	-4.8881
						Salmo salar; Atlantic Salmon	10.4430	-0.1006	0.0709	0.4178	<0.0001	1065	5.20E+08	-8.9376	23.7526	-0.1008	1.7114E+12	-8.9158	4.5913	-0.1004	1.5224E+05	-8.9594	16.9108	-0.1008	6.0383E+10	-8.9248	6.4489	-0.1005	4.4167E+06	-8.9504
						Salmo trutta; Brown Trout	20.1106	-0.2276	0.4741	0.3623	<0.0001	669	5.06E+04	-3.3940	40.9727	-0.2275	1.1628E+06	-3.3965	9.8708	-0.2277	2.2055E+03	-3.3915	30.5249	-0.2275	3.1772E+05	-3.3954	13.2494	-0.2277	8.0530E+03	-3.3925
					Salvelinus		10.3495	-0.1161	0.2546	0.2320	<0.0001	804	2.51E+07	-7.6150	16.3691	-0.1165	1.1968E+09	-7.5827	6.5435	-0.1156	5.1251E+05	-7.6475	13.5421	-0.1163	2.4305E+08	-7.5960	7.9095	-0.1158	2.5723E+06	-7.6340
						Salvelinus alpinus; Arctic Char	2.3132	0.0920	0.0742	0.2891	0.0006	154	-3.55E-06	11.8714	4.2742	0.0855	-1.2726E-09	12.6906	1.2519	0.0984	-3.5219E-03	11.1594	3.3118	0.0882	-3.9569E-08	12.3357	1.6157	0.0958	-2.2415E-04	11.4436
						Salvelinus confluentus; Bull Trout	214.3048	-0.5829	0.8275	0.1097	<0.0001	106	3.11E+03	-0.7155	259.2392	-0.5784	4587.7122	-0.7288	177.1590	-0.5874	2.1215E+03	-0.7025	239.4732	-0.5803	3.8989E+03	-0.7232	191.7816	-0.5855	2.4863E+03	-0.7079
						Salvelinus fontinalis; Brook Trout	10.4112	-0.1048	0.4238	0.1605	<0.0001	454	2.07E+08	-8.5390	14.3089	-0.1052	3.9563E+09	-8.5066	7.5752	-0.1045	1.0603E+07	-8.5716	12.5443	-0.1050	1.1693E+09	-8.5200	8.6408	-0.1046	3.6355E+07	-8.5581

Group	SubGroup	Order	Family	Subfamily	Genus		Linear Regression *U/l* vs *t*						*X*- vs *V*- Equation		95% UPI				95% LPI				75% UPI				75% LPI			
						Species	K	b	R^2	RMSE	p	n	M	a	K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
						Salvelinus namaycush; Lake Trout	2.5551	0.1126	0.6876	0.0084	<0.0001	90	-9.43E-06	9.8833	2.6006	0.1124	-7.9684E-06	9.8941	2.5104	0.1127	-1.1152E-05	9.8726	2.5815	0.1125	-8.5484E-06	9.8896	2.5289	0.1126	-1.0398E-05	9.8771
	Walleye Group (con't) – Grayling swimming performance fit best with Walleye Group																													
				Thymallinae																										
					Thymallus		14.0678	-0.1887	0.4357	0.3468	<0.0001	1390	93645.2054	-4.3006	27.7942	-0.1887	3.4469E+06	-4.2994	7.1203	-0.1886	2540.0829	-4.3018	20.9757	-0.1887	776676.4831	-4.2999	9.4348	-0.1886	11284.7156	-4.3013
						Thymallus arcticus; Arctic Grayling						89																		
						Thymallus thymallus; European Grayling	13.6382	-0.1786	0.4247	0.3396	<0.0001	1301	163526.6992	-4.6001	26.5671	-0.1786	6.8266E+06	-4.5993	7.0012	-0.1785	3912.9134	-4.6009	20.1670	-0.1786	1460036.2425	-4.5996	9.2231	-0.1786	18308.4582	-4.6006
	Trout Freshwater Group- brook, brown, bull, lake, rainbow trouts						16.4446	-0.2000	0.4120	0.3230	<0.0001	2697	9.8517E+04	-4.000																
	Rainbow Trout and Steelhead						7.2718	-0.0794	0.2980	0.2760	<0.0001	3084	2.1634E+09	-11.594																
	Walleye and White Sucker						23.6651	-0.3800	0.9020	0.2100	<0.0001	508	719.6598	-1.6316																

*Table A2c. Summary of **Deming regressions** for **dimensionless** fatigue curves (U· versus t·) with 95% and 75% prediction intervals for selected groups and taxonomic levels. Taxonomy classification from the Intergrated Taxanomic Information System – ITIS. Note: Only main groups and select subgroups were calculated using Deming regressions, however the corresponding least squares regressions (Table A2a) are very similar and can be used in place of the Deming regression where required.*

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Deming Regression U· vs t·						X· vs V· Equation		95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	ChiSQ	p	n	M	a	K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
Catfish and Sunfish Group							2.1758	-0.2019	0.643	59.456		1282	3.8922	-3.9529	3.3257	-0.2021	31.6676	-3.9477	1.4235	-0.2017	0.4763	-3.9582	2.7907	-0.2020	13.3208	-3.9499	1.6964	-0.2018	1.1355	-3.9560
Clupeidae (Herring) Group							10.1188	-0.4018	0.905	7.424		592	59.3403	-1.4888	12.6050	-0.4015	102.9334	-1.4908	8.1231	-0.4021	34.2393	-1.4868	11.5108	-0.4016	81.9670	-1.4900	8.8952	-0.4020	42.9726	-1.4876
Eel Group							3.7221	-0.3672	0.844	124.715		1747	5.9823	-1.7233	6.2954	-0.3672	25.0169	-1.7230	2.2007	-0.3672	1.4301	-1.7236	5.0663	-0.3672	13.8498	-1.7231	2.7346	-0.3672	2.5838	-1.7235
		Anguilliformes																												
			Anguillidae																											
					Anguilla																									
						Anguilla anguilla; European Eel	5.3463	-0.4267	0.715	58.9462		623	10.2738	-1.3436	9.7816	-0.4262	42.5246	-1.3463	2.9221	-0.4272	2.4904	-1.3408	7.6187	-0.4264	23.6205	-1.3452	3.7517	-0.427	4.4738	-1.3419
		Gadiformes																												
			Gadidae																											
					Lota																									
						Lota lota; Burbot	3.4563	-0.3213	0.677	15.1568		100	6.7252	-2.1124	7.9407	-0.3265	82.3862	-2.0628	1.5044	-0.3161	0.5057	-2.1636	5.6142	-0.3243	29.2892	-2.0836	2.1278	-0.3183	1.5022	-2.1417
		Petromyzontiformes																												
			Petromyzontidae																											
					Petromyzon																									
						Petromyzon marinus; Sea Lamprey	3.7648	-0.3778	0.955	23.9067		1000	5.7786	-1.6469	5.1059	-0.3778	12.9446	-1.6469	2.7760	-0.3778	2.5796	-1.6469	4.5015	-0.3778	9.2735	-1.6469	3.1487	-0.3778	3.6008	-1.6469
Pike Group (data)							2.9441	-0.2994	0.463	4.219		138	4.7968	-2.3400	4.6054	-0.3112	18.4429	-2.2130	1.8821	-0.2876	1.1193	-2.4774	3.8236	-0.3063	10.6662	-2.2647	2.2669	-0.2925	2.0789	-2.4189
Pike Group (Derived)- curve derived by assuming burst performance similar to Salmon and Walleye and Eel groups							3.8114	-0.3290					8.5116	-2.0395	5.9621	-0.3290	33.1611	-2.0395	2.4365	-0.3290	2.1847	-2.0395	4.9500	-0.3290	18.8385	-2.0395	2.9347	-0.3290	3.8457	-2.0395
Sturgeon							0.7560	-0.1304	0.686	22.651		1008	0.0060	-6.6687	1.0175	-0.1304	0.0587	-6.6680	0.5617	-0.1304	0.0006	-6.6694	0.8999	-0.1304	0.0229	-6.6683	0.6351	-0.1304	0.0016	-6.6691
Salmon and Walleye							4.0040	-0.2504	0.701	1933.148		17085	26.9191	-2.9936	7.7442	-0.2504	374.9911	-2.9935	2.0702	-0.2504	1.9320	-2.9938	5.8971	-0.2504	126.3299	-2.9935	2.7186	-0.2504	5.7356	-2.9937
	Walleye Group						4.3606	-0.2497	0.673	850.2362		8470	38.3500	-3.0048	8.1202	-0.2497	462.4084	-3.0046	2.3416	-0.2497	3.1799	-3.0050	6.2808	-0.2497	165.3274	-3.0047	3.0274	-0.2497	8.8952	-3.0049
		Perciformes																												
			Percidae																											
					Sander																									
						Sander vitreus; Walleye	11.3090	-0.4223	0.965	4.4173		221	62.2483	-1.3680	14.9702	-0.4219	121.4999	-1.3701	8.5432	-0.4227	31.9306	-1.3658	13.3262	-0.4221	92.0530	-1.3692	9.5972	-0.4225	42.1112	-1.3667
	Salmon and Trout Group						3.736	-0.2532	0.748	953.952		8615	19.513	-2.949	7.1723	-0.2532	256.2284	-2.9491	1.9464	-0.2532	1.4854	-2.9498	5.4784	-0.2532	88.4411	-2.9493	2.5482	-0.2532	4.3045	-2.9496
				Salmoninae																										
					Oncorhynchus		3.6550	-0.2649	0.856	477.0496		6077	15.0350	-2.7750	6.3385	-0.2649	120.0932	-2.7748	2.1076	-0.2649	1.8818	-2.7753	5.0490	-0.2649	50.9001	-2.7749	2.6459	-0.2649	4.4406	-2.7752
						Oncorhynchus kisutch; Coho Salmon	3.2877	-0.2405	0.638	72.026		549	14.2260	-3.1580	6.7612	-0.2411	280.3575	-3.1477	1.5987	-0.2399	0.7112	-3.1684	5.0173	-0.2409	81.7302	-3.1511	2.1544	-0.2401	2.4618	-3.1649
						Oncorhynchus mykiss; Rainbow Trout	3.214	-0.2537	0.554	68.200		1217	10.696	-2.942	5.1293	-0.2539	67.1834	-2.9382	2.0142	-0.2535	1.6973	-2.9452	4.2282	-0.2538	31.4444	-2.9396	2.4435	-0.2536	3.6342	-2.9437
						Oncorhynchus mykiss; Steelhead Trout	3.653	-0.2682	0.908	92.011		1867	14.335	-2.729	5.6511	-0.2681	73.0296	-2.7297	2.3616	-0.2683	2.8166	-2.7274	4.7188	-0.2682	37.2587	-2.7292	2.8282	-0.2682	5.5172	-2.7279
						Oncorhynchus tshawytscha; Chinook Salmon	4.0678	-0.2794	0.891	86.9757		1214	18.2037	-2.5791	6.8861	-0.2794	119.7808	-2.5791	2.4030	-0.2794	2.7665	-2.5791	5.5395	-0.2794	54.9735	-2.5791	2.9871	-0.2794	6.0279	-2.5791
	Trout Freshwater Group – brook, brown, bull, lake and rainbow trouts						4.745	-0.2751	0.565	281.062		2697	33.844	-2.635	8.9446	-0.2752	338.1590	-2.6336	2.5172	-0.2750	3.3810	-2.6365	6.8832	-0.2752	130.6578	-2.6342	3.2711	-0.2750	8.7609	-2.6359
	Rainbow Trout and Steelhead						3.636	-0.2677	0.911	160.594		3084	14.182	-2.736	5.6867	-0.2677	75.3808	-2.7354	2.3249	-0.2677	2.6682	-2.7356	4.7273	-0.2677	37.8013	-2.7355	2.7967	-0.2677	5.3209	-2.7356
	Walleye and White Sucker						8.9281	-0.3917	0.948	10.7151		508	48.4120	-1.5530	11.8710	-0.3913	100.7106	-1.5556	6.7147	-0.3921	23.3067	-1.5504	10.5508	-0.3914	74.4207	-1.5549	7.5549	-0.392	31.5137	-1.5510

Table A2d. Summary of Deming regressions for fatigue curves in body lengths per second (U/l versus t) with 95% and 75% prediction intervals for selected groups and taxonomic levels. Taxonomic classification is from the Integrated Taxonomic Information System - ITIS. Note: Only select groups were calculated using Deming regressions, however the corresponding least squares regressions (Table A2b) are very similar and can be used in place of the Deming regression where required.

Group	SubGroup	Order	Family	Subfamily	Genus	Species	Deming Regression *U/l vs t*						X. vs V. Equation		95% UPI				95% LPI				75% UPI				75% LPI			
							K	b	R^2	ChiSQ	p	n	M	a	K_U95	b_U95	M_U95	a_U95	K_L95	b_L95	M_L95	a_L95	K_U75	b_U75	M_U75	a_U75	K_L75	b_L75	M_L75	a_L75
Eel Group							11.2099	-0.3677	0.670	79.5011		1747	119.5827	-1.7196	21.0942	-0.3677	6.6737E+02	-1.7196	5.9572	-0.3677	2.1427E+01	-1.7196	16.2436	-0.3677	3.2790E+02	-1.7196	7.7361	-0.3677	4.3611E+01	-1.7196
		Anguilliformes																												
			Anguillidae																											
					Anguilla																									
						Anguilla anguilla; European Eel	18.0817	-0.4588	0.6696	79.5011		623	122.2840	-1.1796	36.4704	-0.4580	5.7073E+02	-1.1834	8.9647	-0.4596	2.6342E+01	-1.1758	27.2840	-0.4583	3.0170E+02	-1.1820	11.9831	-0.4593	4.9661E+01	-1.1772
		Gadiformes																												
			Gadidae																											
					Lota																									
						Lota lota; Burbot	16.1497	-0.3862	0.670	23.482		100	238.9207	-1.5893	44.7504	-0.3920	2.9467E+03	-1.5510	5.8282	-0.3804		-1.6288	29.2594	-0.3896	1.0429E+03	-1.5667	8.9138	-0.3828	5.3327E+01	-1.6123
		Petromyzontiformes																												
			Petromyzontidae																											
					Petromyzon																									
						Petromyzon marinus; Sea Lamprey	9.8562	-0.3624	0.917	39.4172		1000	90.6436	-1.7594	14.5763	-0.3624	2.6685E+02	-1.7594	6.6645	-0.3624	3.0790E+01	-1.7594	12.3988	-0.3624	1.7075E+02	-1.7594	7.8350	-0.3624	4.8118E+01	-1.7594
Salmon and Walleye							12.794	-0.156	0.310	2970.776		17085	7.7782E+05	-5.410	28.966	-0.1560	1.4624E+08	-5.4098	5.651	-0.1560	4.1341E+03	-5.411	20.6678	-0.1560	1.6813E+07	-5.4100	7.9203	-0.1560	35974.3515	-5.4105
	Walleye Group						20.683	-0.2287	0.440	1581.522		8470	5.3886E+04	-3.373	48.3000	-0.2287	2.1960E+06	-3.3723	8.8567	-0.2287	1.3217E+03	-3.373								
		Perciformes																												
			Percidae																											
					Sander																									
						Sander vitreus, Walleye	31.620	-0.4342	0.933	8.9785		221	5.8876E+02	-1.303	21.1520	-0.4347	2.3161E+02	-1.3003					40.0086	-0.4339	1017.47335	-1.3047	24.9908	-0.4345	340.955279	-1.3014
	Salmon and Trout Group						8.634	-0.0989	0.249	939.782		8615	1.1203E+08	-9.111	16.4973	-0.0989	7.7643E+10	-9.1090	4.5186	-0.0989	1.6119E+05	-9.113	12.6253	-0.0989	5208005107	-9.1099	5.9044	-0.0989	2407572	-9.1125
				Salmoninae																										
					Oncorhynchus		7.8022	-0.0927	0.330	484.9117		6077	1.5077E+08	-9.787	13.5884	-0.0927	5.9596E+10	-9.7853	4.4798	-0.0927	3.8052E+05	-9.790	10.8049	-0.0927	5040657267	-9.7862	5.0339	-0.0927	4505995.77	-9.7888
						Oncorhynchus kisutch; Coho Salmon	5.7489	-0.0300	0.024	53.8522		549	2.3376E+23	-32.3333	10.7167	-0.0307	4.0927E+31	-31.5733	3.0839	-0.0293	5.3940E+14	-33.1297	8.2821	-0.0304	1.8084E+28	-31.8947	3.9904	-0.0296	2.2296E+18	-32.7838
						Oncorhynchus mykiss; Rainbow Trout	12.933	-0.1805	0.215	112.536		1217	1.0544E+05	-4.540	23.5461	-0.1808	2.8343E+06	-4.5307	7.1039	-0.1802	3.8786E+03	-4.5497	18.3803	-0.1807	728036.3521	-4.5346	9.1004	-0.1803	15212.2251	-4.5457
						Oncorhynchus mykiss; Steelhead Trout	6.760	-0.0468	0.153	96.292		1867	9.5492E+15	-20.368	10.5406	-0.0467	1.4159E+20	-20.4161	4.3352	-0.0469	6.7265E+11	-20.3191	8.7727	-0.0467	2.66056E+18	-20.3960	5.2088	-0.0469	3.4791E+13	-20.3391
						Oncorhynchus nerka; Sockeye Salmon																								
						Oncorhynchus tshawytscha; Chinook Salmon	8.7155	-0.1181	0.513	84.8057		1214	4.2315E+06	-7.4674	14.6538	-0.1181	3.4454E+08	-7.4674	5.1836	-0.1181	5.1969E+04	-7.4674	11.8213	-0.1181	5.5892E+07	-7.4674	6.4257	-0.1181	3.2036E+05	-7.4674
	Trout Freshwater Group – brook, brown, bull, lake and rainbow trouts						17.558	-0.2117	0.412	268.961		2697	6.5993E+04	-3.724	32.6283	-0.2118	1.2208E+06	-3.7208	9.4482	-0.2116	3.5546E+03	-3.7266	25.2572	-0.2118	365771.6556	-3.7220	12.2055	-0.2116	11891.8329	-3.7254
	Rainbow Trout and Steelhead						7.313	-0.0806	0.298	232.553		3084	1.6238E+09	-11.407	12.5391	-0.0806	1.3035E+12	-11.4059	4.2646	-0.0806	2.0206E+06	-11.4079	10.0347	-0.0806	82241889261	-11.4064	5.3289	-0.0806	32048755.2	-11.4075
	Walleye and White Sucker						24.0612	-0.3856	0.902	19.4916		508	678.1365	-1.5934	35.3607	-0.3850	1.8635E+03	-1.5974	16.3724	-0.3862	2.4755E+02	-1.5893	30.1535	-0.3853	1.2248E+03	-1.5954	19.1998	-0.3859	3.7580E+02	-1.5913

APPENDIX 3

Data Preparation and Summary Tables Example Appendix 3

Data Preparation and Summary Tables Example

In this Appendix, the data extraction and preparation procedure that was used to assemble the data collection is illustrated using the walleye dataset from Castro-Santos (2005) as an example. As with most datasets that were used in the analysis, the data was extracted from a publication obtained from the literature (peer reviewed journal). Access to the original unprocessed data was not available for this dataset. Published data is usually presented in a processed format, where the raw data collected in the experiment is transformed (e.g. swimming speed is converted from m/s to body lengths per second) or the data is grouped into categories (based on size, treatment or other criteria) and average results are presented to support the study objectives and conclusions.

The Castro-Santos (2005) paper presented the results from a series of high-speed open channel flume volitional swim tests for six fish species. Maximum distance of ascent was measured for individual fish for different water velocities. The published data included a series of graphs (Fig. A3 -1) that present time to fatigue as a function of swim speed for individual fish that attempted to swim the flume. Data was extracted from the graphs by digitizing the individual data points which were recorded and archived in a database.

Figure A3-2 shows a replot of the extracted walleye dataset, which is also used to verify accuracy of extracted data. For walleye, all data points in the original plot were distinct and easily captured, however for American shad (Fig A3-1), the density of points limited the number of individual data points that could be detected and extracted. American shad data points that were not captured had a minimum impact on the performance estimates because the overall trend of the data was retained in the data points that were extracted.

Swim speed in the Castro-Santos (2005) graphs is presented in body lengths per second (BL/s or Ls^{-1}), which is a calculated value, where the swim speed (m/s) of a fish is divided by its length (m) to produce a relative speed. This transformation is used to account for size differences in performance. Actual swim speeds (m/s) required for the analysis had to be estimated using other fish length information in the publication. Relative swim speed (BL/s) was converted to actual swim speed (m/s) using average fish length data from Table A3-1 of the publication. Corresponding fish lengths for the individual data points were not available. The use of average fish length did introduce some error into the conversion; however based on the standard deviations shown in Table 1, the variation in length was quite small for most fish species which limited the error. Striped bass were the exception, they had a significantly larger standard deviation compared to the other species and they were the largest fish which had the potential to produce higher conversion errors. The largest conversion errors typically occur at the highest and lowest swim speeds where fish size has the greatest effect on relative swim speeds (i.e. smaller fish produce higher relative swim speeds). For example, the highest relative swim speed from the striped bass graph was 20 BL/s which for a smaller fish length (150 mm) would result in a corresponding swim speed of 3 m/s and for a larger fish length (800 mm) the swim speed would be 16 m/s. For the average length of 500 mm the swim speed would be 10 m/s. This highlights how fish size can significantly affect swim speeds when reported in BL/s and the potential for bias in the data distribution and corresponding regressions analysis if size effects are not addressed correctly.

In Figure A3-3, the walleye dataset is replotted with swim speed converted to m/s based on average fish length and the logarithm of fatigue time is transformed to a logarithmic scale (easier to understand, no conversion needed).

Data grouping was also part of the data formatting process and the rationale behind grouping is described in the main document. Figure A3-4 shows the grouped data points that were produced for the walleye group, superimposed with the raw data points.

Table A3-1. *Summary of fish length data Castro-Santos (2005) open channel volitional swim test.*

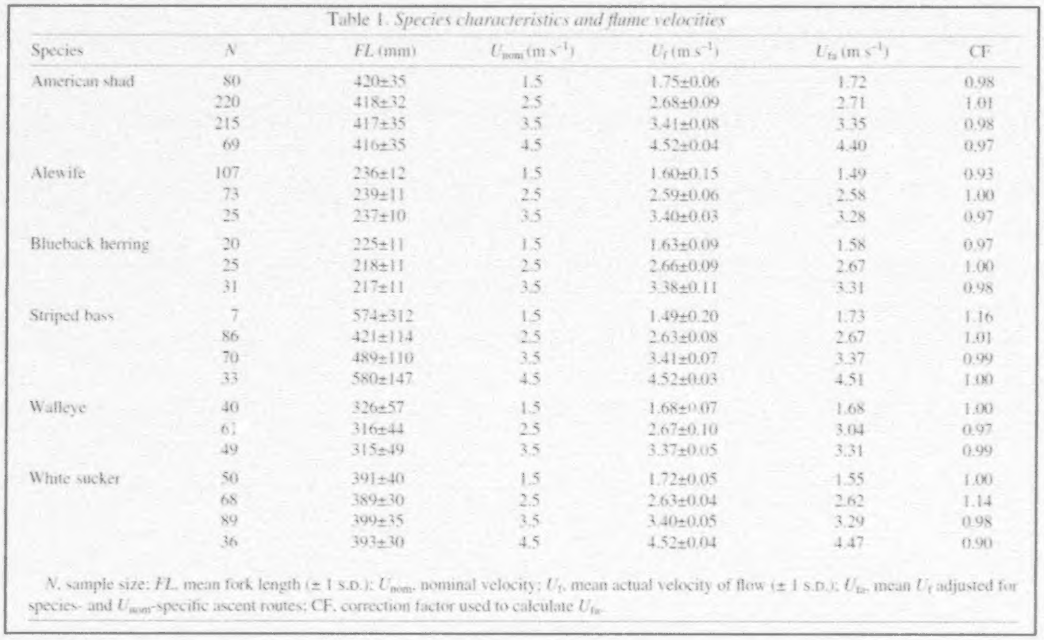


Table 1. *Species characteristics and flume velocities*

Species	*N*	*FL* (mm)	U_{nom} (m s^{-1})	U_f (m s^{-1})	U_{fa} (m s^{-1})	CF
American shad	80	420±35	1.5	1.75±0.06	1.72	0.98
	220	418±32	2.5	2.68±0.09	2.71	1.01
	215	417±35	3.5	3.41±0.08	3.35	0.98
	69	416±35	4.5	4.52±0.04	4.40	0.97
Alewife	107	236±12	1.5	1.60±0.15	1.49	0.93
	73	239±11	2.5	2.59±0.06	2.58	1.00
	25	237±10	3.5	3.40±0.03	3.28	0.97
Blueback herring	20	225±11	1.5	1.63±0.09	1.58	0.97
	25	218±11	2.5	2.66±0.09	2.67	1.00
	31	217±11	3.5	3.38±0.11	3.31	0.98
Striped bass	7	574±312	1.5	1.49±0.20	1.73	1.16
	86	421±114	2.5	2.63±0.08	2.67	1.01
	70	489±110	3.5	3.41±0.07	3.37	0.99
	33	580±147	4.5	4.52±0.03	4.51	1.00
Walleye	40	326±57	1.5	1.68±0.07	1.68	1.00
	61	316±44	2.5	2.67±0.10	3.04	0.97
	49	315±49	3.5	3.37±0.05	3.31	0.99
White sucker	50	391±40	1.5	1.72±0.05	1.55	1.00
	68	389±30	2.5	2.63±0.04	2.62	1.14
	89	399±35	3.5	3.40±0.05	3.29	0.98
	36	393±30	4.5	4.52±0.04	4.47	0.90

N, sample size; *FL*, mean fork length (± 1 S.D.); U_{nom}, nominal velocity; U_f, mean actual velocity of flow (± 1 S.D.); U_{fa}, mean U_f adjusted for species- and U_{nom}-specific ascent routes; CF, correction factor used to calculate U_{fa}.

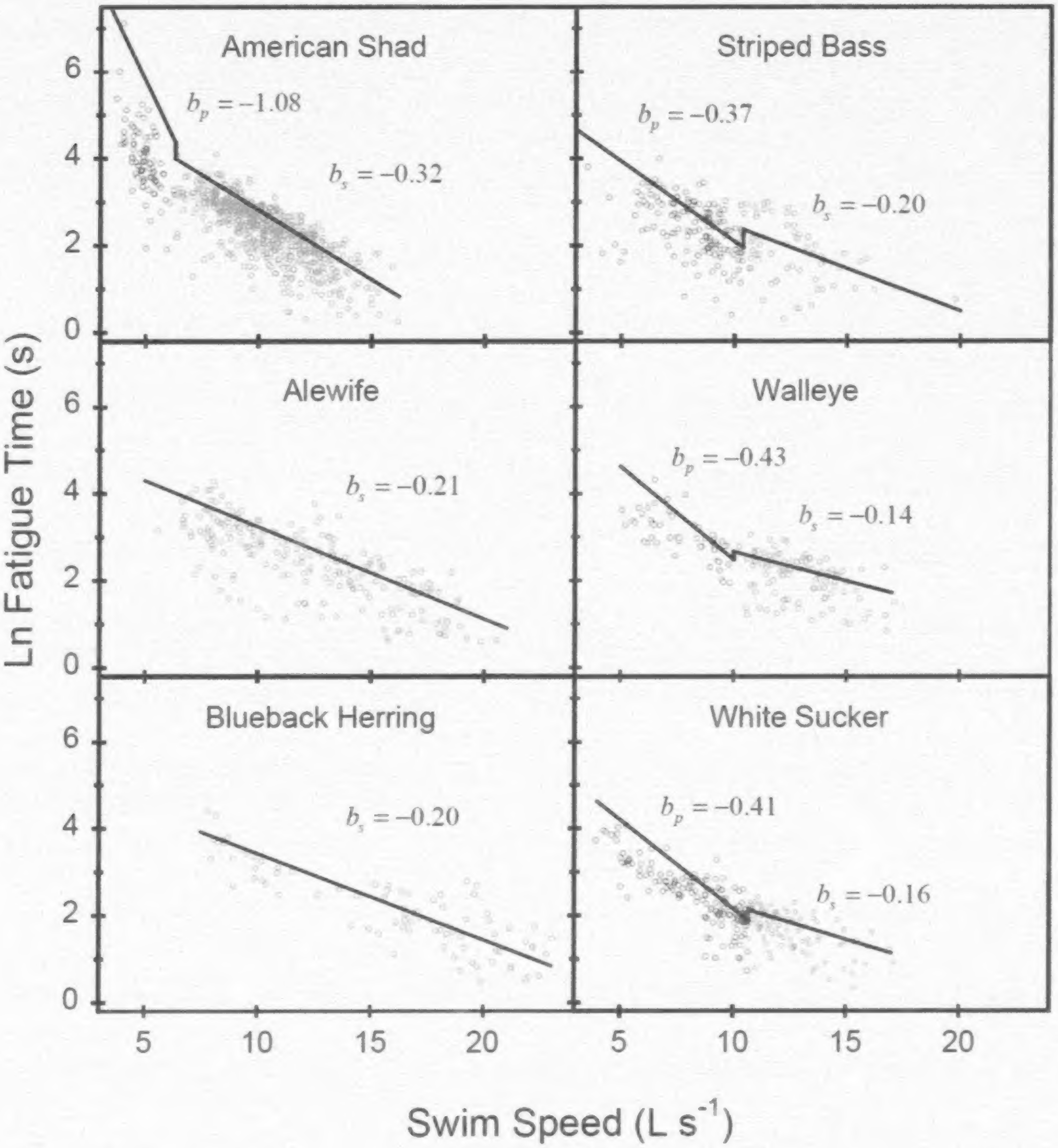


Figure A3-1. *Copy of the original swim speed-fatigue time data by species from Castro-Santos (2005).*

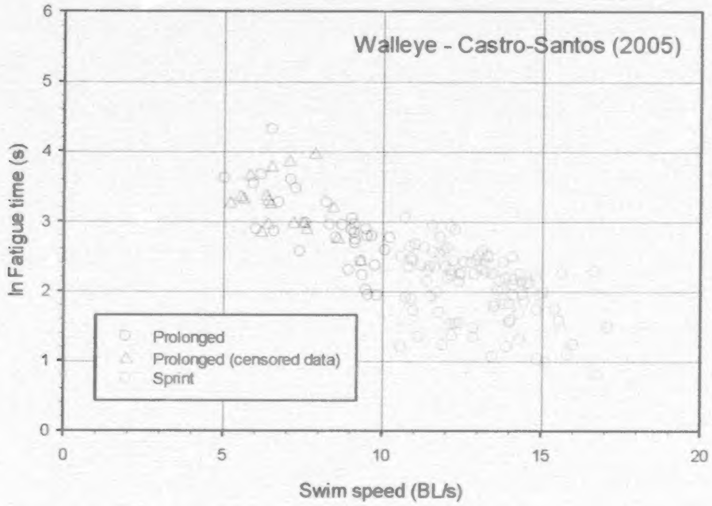


Figure A3-2. Replot of walleye dataset extracted from Figure A3-1.

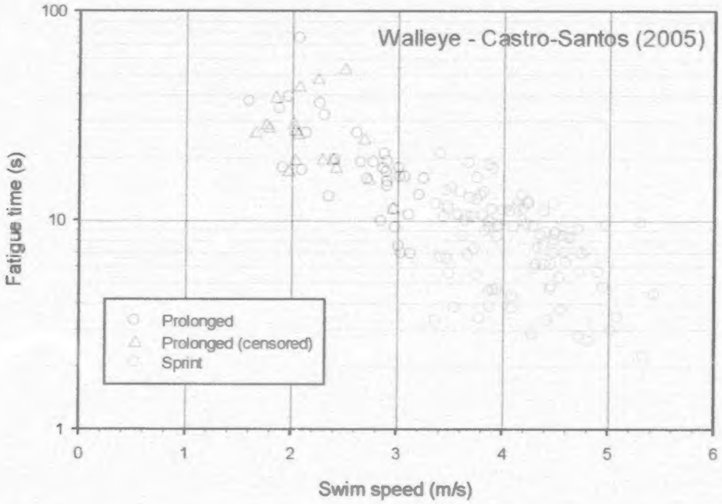


Figure A3-3. Replot of walleye dataset with swim speed converted from body lengths per second to m/s and fatigue time converted from natural logarithm and replotted using logarithmic scale.

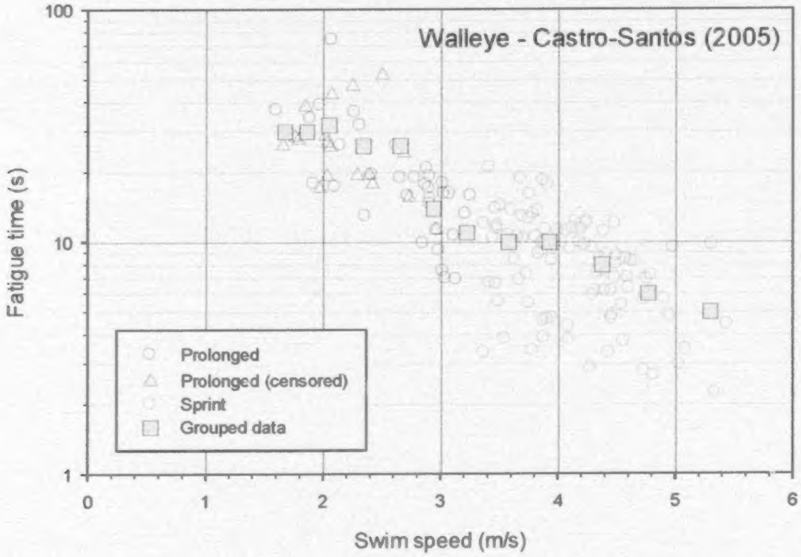


Figure A3-4. *Walleye dataset grouped data (processed) overlaid with ungrouped data points. Data was grouped by separating the swim speed data in series of subgroups where the maximum difference in swimming speed within each group was 10% or less. The corresponding median swim time was calculated for each swim speed subgroup.*

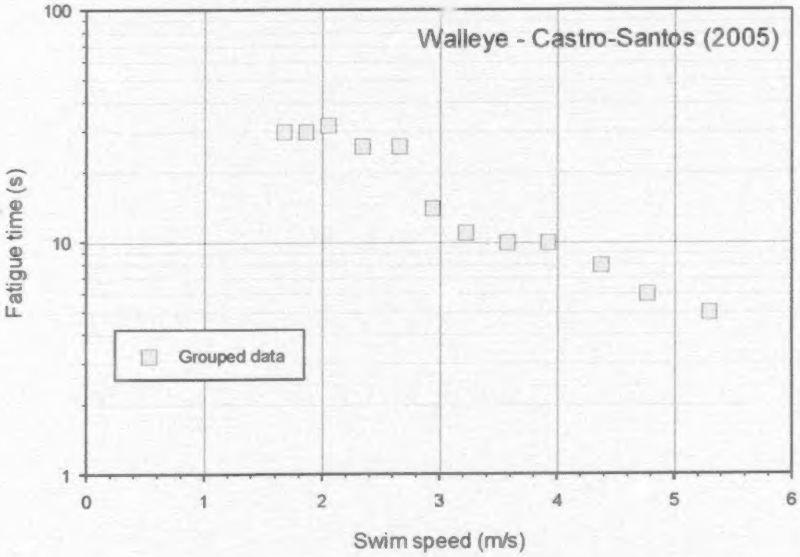


Figure A3-5*. Plot of processed Castro-Santos (2005) walleye swim speed versus time to fatigue data.*

Overview of Summary Tables for Graphs

Many graphs include a corresponding summary table of statistical information about the underlying data. The summary tables include: the mean; standard deviation (SD); minimum (Min); maximum (Max); data range and counter (number of unique values) for the variables: fish length ($l\ (m)$); water temperature ($T(^0C)$) ; swimming speed (U); and swim time (endurance time) where $t_{\Delta t}$ *(s)* is from the swim time from the increasing velocity test and t_e *(s)* is swim time for all other test methods. To provide some insight about the test methods reflected in a dataset, swim time data from the increasing velocity test (critical swim speed) is distinguished from other test methods. A fish count and record count are also included for each table.

Table A3-2. Summary table Castro-Santos (2005) – Walleye processed data.

Variables	Mean	SD	Min	Max	Range	N
l *(m)*	0.318	0	0.318	0.318	0	1
T *(^0C)*	13.6	0	13.6	13.6	0	1
U *(m/s)*	3.22	1.18	1.67	5.29	3.62	12
t_e *(s)*	16.0	9.1	3.9	30.9	27.0	12
$t_{\Delta t}$ *(s)*	.	.	.	.	.	0
Fish count: 146 **Record count**: 12						

The processed Castro-Santos (2005) walleye data from the previous section will be used as an example to illustrate how summary tables were created. The summary data table (Table A3-2) is based on the processed walleye data collection shown in Table A3-3 (Figure A3-5).

Table A3-3. Processed walleye data Castro-Santos (2005).

Record	l *(m)*	T *(^{0} C)*	U *(m/s)*	t_e *(s)*	*Fish Count*
1	0.318	13.6	3.57	10.4	21
2	0.318	13.6	3.92	9.5	25
3	0.318	13.6	4.37	8.25	28
4	0.318	13.6	4.76	6.9	15
5	0.318	13.6	5.29	3.9	4
6	0.318	13.6	2.94	14.6	15
7	0.318	13.6	3.22	11.9	7
8	0.318	13.6	1.67	28.5	3
9	0.318	13.6	1.86	30.9	4
10	0.318	13.6	2.05	26.4	10
11	0.318	13.6	2.34	19.5	8
12	0.318	13.6	2.65	21.6	6

Each of the records in Table A3-3 was derived from grouped data which corresponds to the mean performance of a combination of related data (e.g. fish of similar in length (i.e. 10% or less difference in length). For example the first record is based on data from 21 fish (fish count).

To produce the summary table, statistics are calculated for each variable (e.g. length, temperature, etc.). For this dataset, each of the 12 records that make up this dataset has the same fish length value because individual fish lengths were not available and the average fish length was used for all. When length data for the 12 records is summarized, the standard deviation is zero because all records have the same value and the counter (N) is equal to one because all fish in this group have the same length. The counter is used to track unique values for each variable which is helpful in understanding the assortment of data available for that variable. The variables in a dataset may have different values for counters depending on the assortment of the underlying data. For example, the walleye dataset contains 12 data records where fish length for all 12 records is the same and this counter is equal to one, however the swim speed and endurance time are different for each of the 12 records and their counters are 12. The summary tables are intended to support the graphs by providing additional information about the underlying data for example the fish lengths reflected in a particular graph.

The summary tables also include a fish count and record count that identify the total number of fish and the number of data records for the dataset reflected in the graph. For the walleye example, 12 records were used to produce the summary table and these 12 records were based on 146 individual fish.

List of Symbols

U	Swim speed (m/s)
U_*	Dimensionless swim speed
t	Endurance time (time to fatigue; seconds)
t_*	Dimensionless time to fatigue
$t_e\ (s)$	Endurance time (seconds)
$t_{\Delta t}\ (s)$	Time step for increasing velocity test (seconds)
l	Fish length (m)
U/l	Relative swim speed in body lengths per second
g	Gravitational constant; 9.81 m/s^2
V	Water velocity (m/s)
V_*	Dimensionless water velocity
X	Maximum swim distance (m)
X_*	Dimensionless swim distance
$T(C)$	Water temperature (degrees Celsius)
SEE	Standard error of estimate
R^2	Coefficient of determination